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Monthly Bulletin of the International Railway Congress Association

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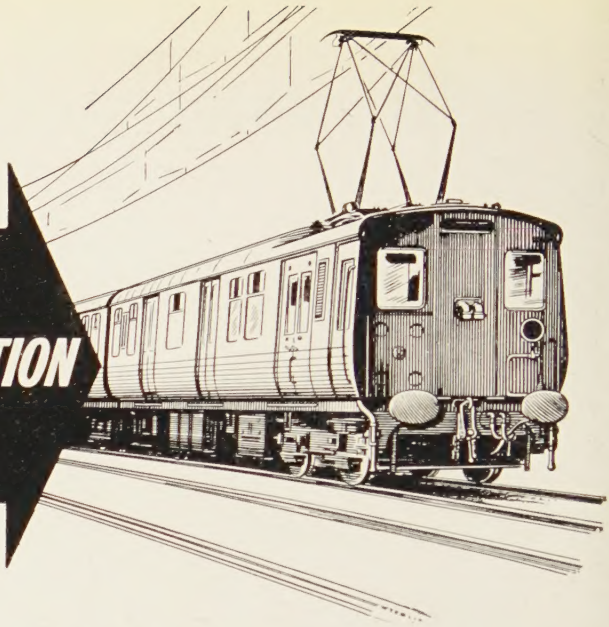

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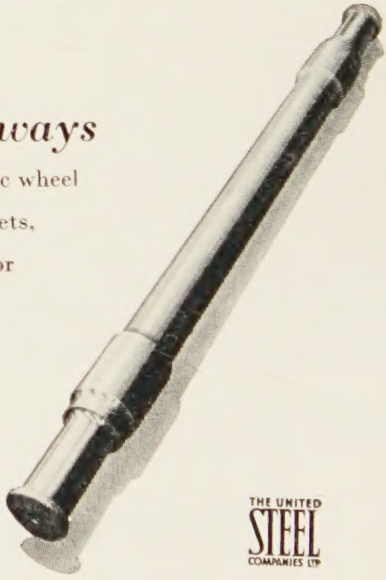

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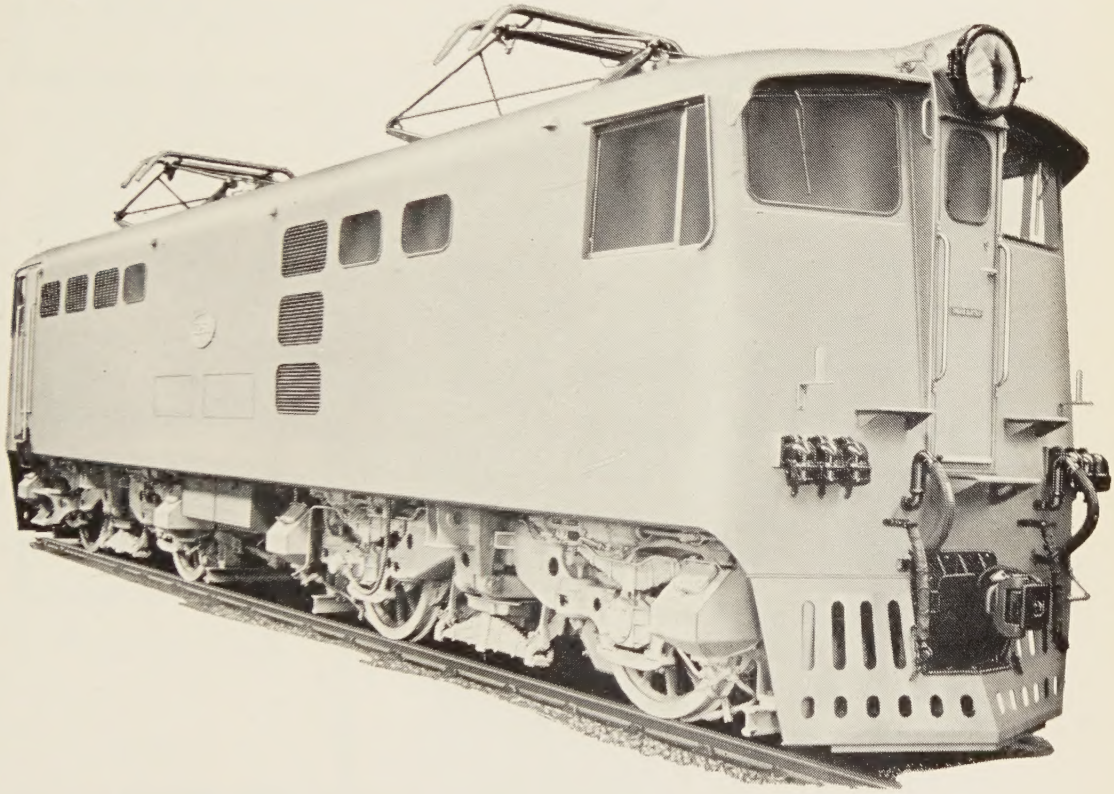

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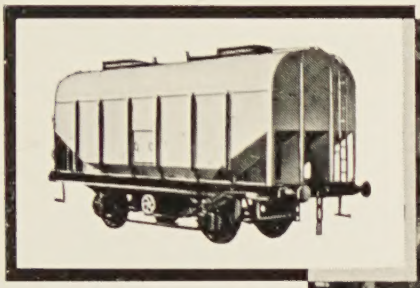

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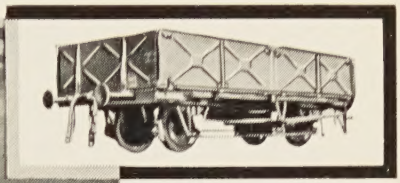

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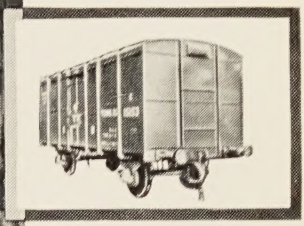
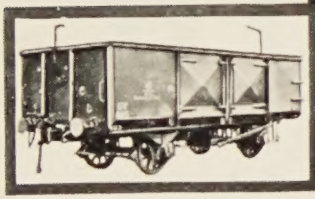
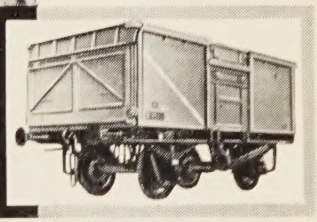


Broad gauge covered Wagon type C.R. as used by Indian Railways



22-ton G.Y. type Wagon as used by the Victoria Government Railways, Australia



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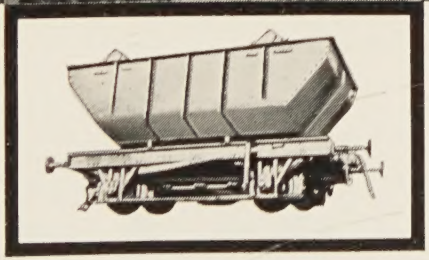

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An edition in French is also published.

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BULLETIN
OF THE
INTERNATIONAL RAILWAY CONGRESS
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(ENGLISH EDITION)

[625 .285]

The Diesel-electric motor coach sets of the Netherlands Railways and Swiss Federal Railways for international passenger traffic.

INTRODUCTION.

The Administrations of the Belgian, French, West German, Italian, Netherlands and Swiss State Railways have put in hand a common organisation of fast, comfortable railway services linking up the main cities of Western Europe. Many of these countries have built special rolling stock for this purpose and have drawn up common regulations regarding construction and operating principles : for example, all the fast services in question will be worked by railcars having about the same standard of comfort with their outside walls painted the same colour. These trains have been christened « Trans - Europ - Express ». In general, they work very fast day services over distances of 600 to 800 km (372 to 500 miles).

The above mentioned Administrations, members of the T.E.E. organisation, with the exception of Belgium and Luxemburg, have all built some new rakes for this special purpose. Each rake (motor unit and coaches) is a unit driven by one or several Diesel engines with electric or hydraulic drive; they do not therefore require any outside source of power, and so can run over all the international lines in question. The T.E.E. rakes, all of the same colour, also carry the same inscriptions and the same symbol.

The French National Railways, the German Federal Railways and the Italian State Railways have each built their own trains. On the other hand, the Netherlands Railways (N.S.) and the Swiss Federal Railways (C.F.F.) have formed a pool. The five T.E.E. units they are running are of the same design. The only difference is the colour of the seats, chairs, walls and floor. The five N.S. C.F.F. T.E.E. rakes (fig. 1) each consist of a motor unit with service compartments and three coaches, the rear one of which is fitted as a control coach. To accentuate this international co-operation, the N.S. and the C.F.F. placed a joint order with an industrial Swiss/Dutch group, for the delivery of the above mentioned units. As a result of subsequent negociations the Werkspoor Shops were given the order for the mechanical parts,

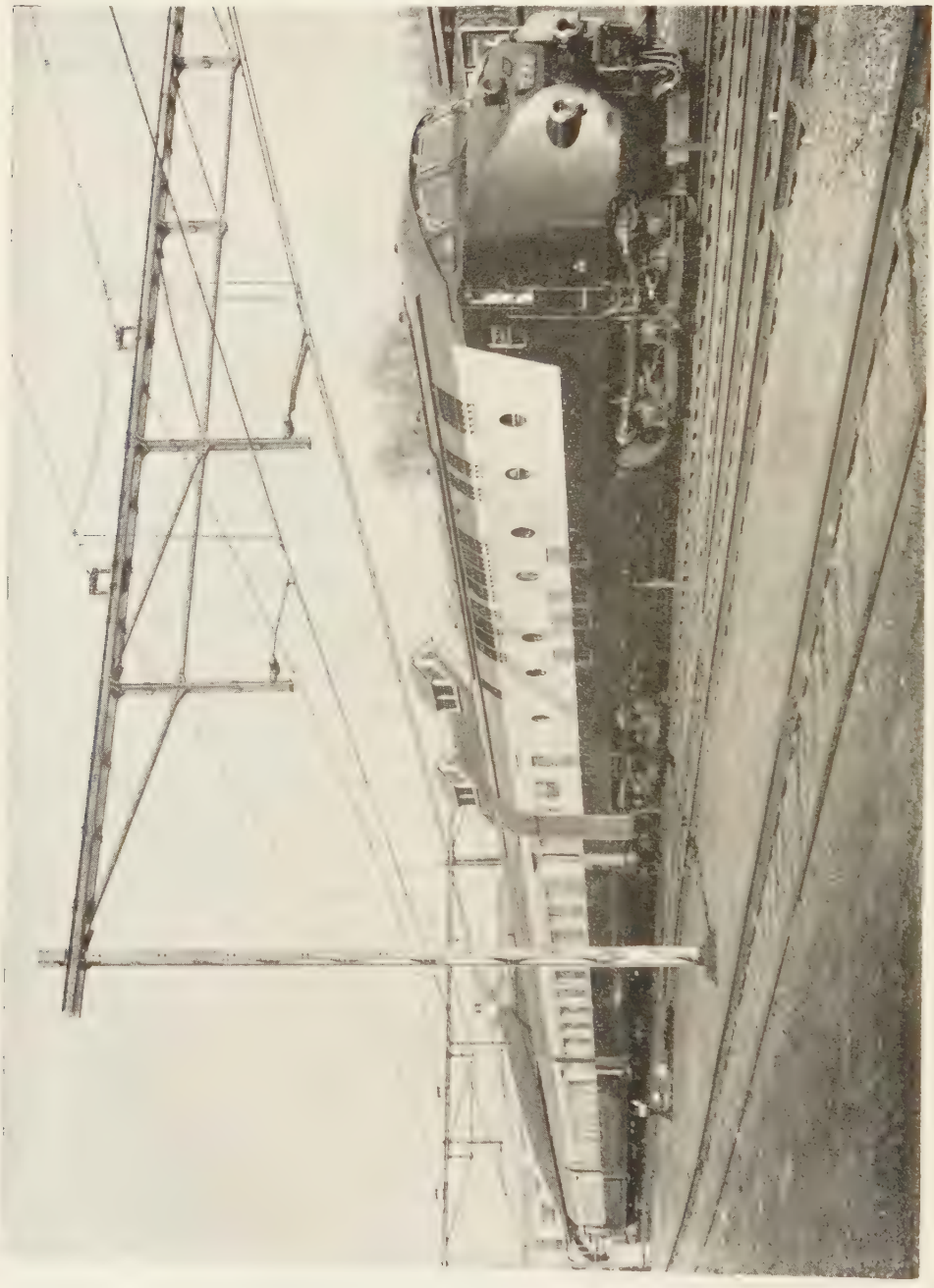

Fig. 1 — Exterior view of a T.E.E. rake belonging to the Netherlands Railways and Swiss Federal Railways.

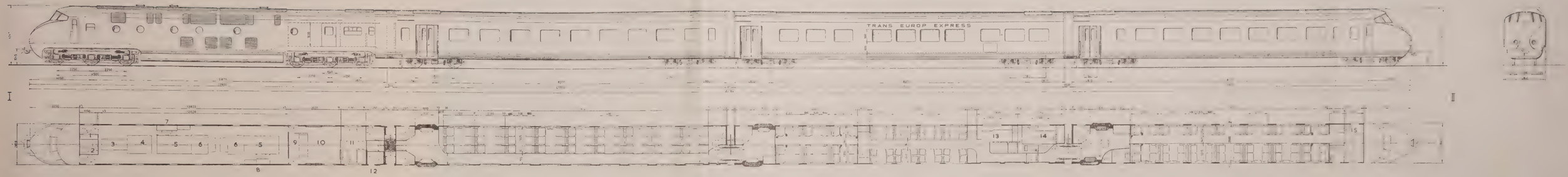

Fig. 2. — General plan and view of the rakes.

1. Equipment.
2. Driver.
3. Auxiliary generator (three-phase current).
4. R. U. B. 168 auxiliary Diesel engine.
5. R. U. H. B. 1616 Diesel engine.
6. Main generator.
7-8. Equipment cupboard.
9. Air compressor.
10 Luggage compartment.
11. Customs.
12. Guard.
13. Office.
14. Kitchen.
15. Bunk for train staff.

as well as the heating equipment of the railcars, and Messrs Brown Boveri & Co., Baden, the manufacture of the electrical equipment. The coaches were ordered from the Swiss Industrial Company at Neuhausen.

The N.S. and the C.F.F. have three and two rakes respectively which they operate in common. They have formed a pool for this purpose. The capital and operating costs, i.e. the interest and sinking fund charges for the capital invested and operating and maintenance costs on the one hand, and the operating receipts on the other hand are dealt with in a common account and the profits divided up according to the number of vehicles owned by each administration.

MOTOR UNITS

As the drawing (fig. 2) shows, there is a driving compartment at each end of the train. In one direction of running, the coaches are hauled, and in the other, pushed. A remote control installation makes it possible to drive two coupled up rakes from one driving compartment. The end couplings are of the Scharfenberg type automatic coupling (fig. 3) on which are fitted the coupling equipment for the electric wiring for the distant control and the compressed air pipes. The coaches, both motor and trailer, are linked together by rigid couplings of the Netherlands type. There are 114 seats and 32 restaurant car seats in a rake. The total weight is 225 t. The motor unit alone weighs 115 t and has an adhesive weight of 76 t. The total overall length is 98 m. In the engine compartment (fig. 4) of the motor unit, there are two Diesel-electric traction groups each of 1 000 HP, and an auxiliary Diesel-electric group with 300 HP engine. The Diesel engines (fig. 5) are four stroke engines with turbo-compressor and air cooling at the intake to the cylinders. They have 16 cylinders arranged in Vee with a bore of 160 mm and a stroke of 200 mm. The maximum speed is 1 400 r.p.m. The auxiliary Diesel engine is a four stroke engine with eight cylinders in Vee, having a bore of 160 mm and a stroke of 200 mm. The maximum speed is 1 000 r.p.m. The main generators are designed for a voltage of 600 V and a current of 1 250 A at the hourly rating.

The auxiliary generator supplies three phase 220/380 V current, 50 Hz; its power in continuous working is 270 kVA. The four traction motors drive the outer axles of the two three axled bogies of the motor unit. They are designed for a power in continuous working of 292 kW at 580 V and 1 550 r.p.m. The traction motors are attached to the bogie frame through elastic components. The power is transmitted to the axle through a B.B.C. spring drive of well known pattern.

The body of the motor unit is of rigid self-supporting tubular construction (fig. 6). It includes the driver's compartment, the engine compartment which is 13 m long, a 3.5 m long luggage compartment, service compartments for the staff and customs, the train staff and the spare driver, and staff toilets.

Special attention has been devoted to the arrangement of the driving compartments (fig. 7) and to the simplification of the driving, as the rakes will be driven by traction department staff belonging to several different railway administrations.

Fig. 1 — Interior of the engine compartment

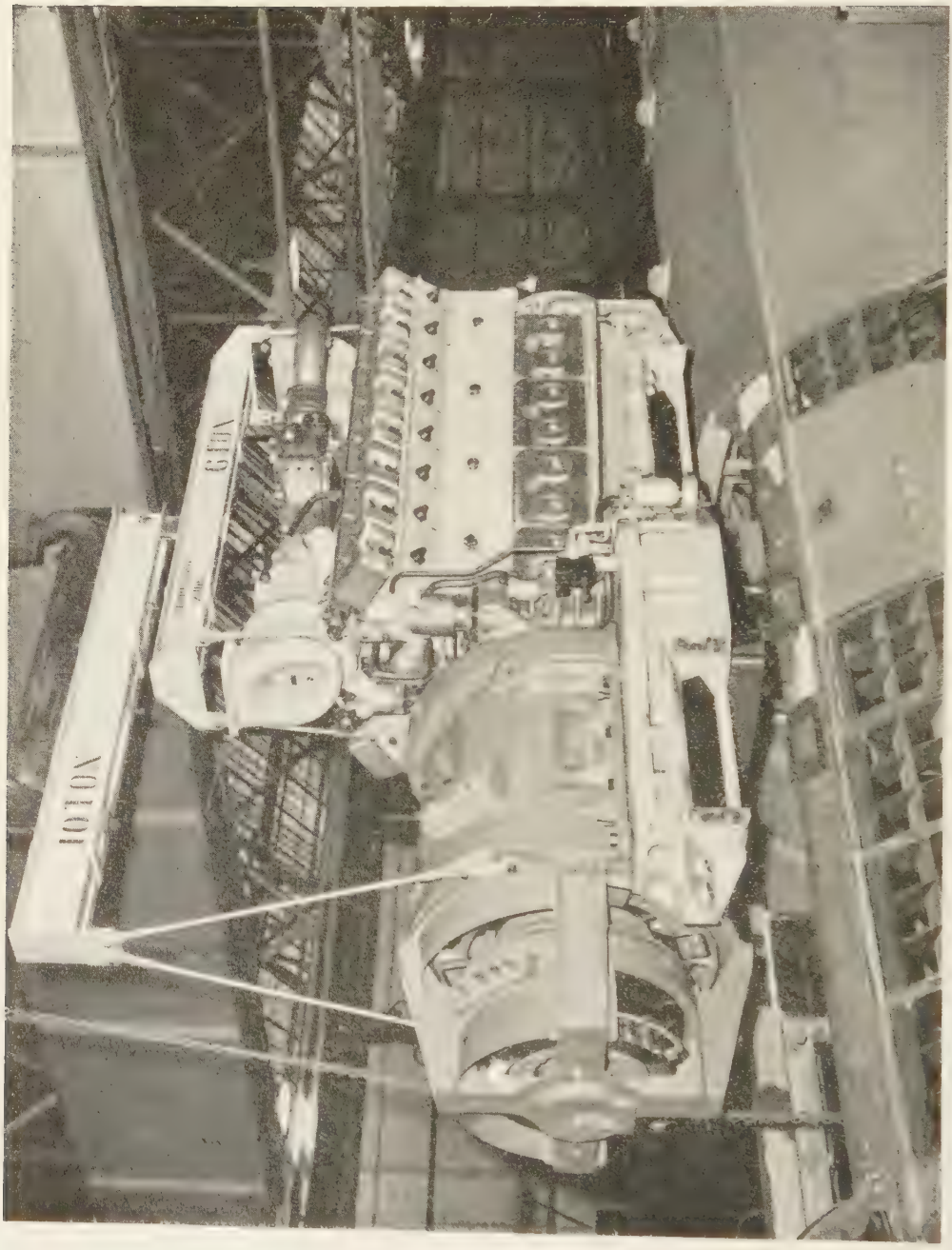

Fig. 5. Assembly of a Diesel unit.

The driver regulates the speed by means of a controller lever; there is in addition in the driving compartment a lever controlling the reverse gear, a brake cock and various switches for the lighting, lamps, etc. The dashboard is fitted with four amperemeters for the traction current, four rev. counters for the Diesel traction engines and the pressure gauges for the compressed air brake. On the driver's desk is a Hasler speed recorder with electric drive and various check-lamps. A dead man's handle comes into play if the driver is unable to drive; this cuts the tractive effort and stops the train by means of the compressed air brake. The controller has eight notches. The seven first notches regulate the power of the Diesel set and the eighth reduces the field of the traction motors. The Diesel traction sets are controlled by a Woodward regulator coupled to a field rheostat with servo-motor, Brown Boveri system. The D.C. traction generator is coupled directly to the Diesel engine. An auxiliary 50 kW generator is coupled to the end of the shaft of the traction generator. This supplies the D.C. current required for the fan motors, the compressors, the emergency lighting, charging the batteries and the service requirements. Each main generator supplies two traction motors permanently coupled in parallel. The Diesels are started by the generators which are supplied by a battery of alcaline 90 cell 300 Ah accumulators and then work as starting motors.

The auxiliary three - phase current generator supplies the power for the lighting, the heating, the air conditioning, the cooling water reheaters, the kitchen and the loudspeaker installation.

The Diesel engines are water cooled, the radiators on the roof being cooled by fans driven by electric motors. The temperature is regulated by thermostats. The cooling water also circulates through the oil coolers. It is possible when the Diesel engines are stationary for a long period to reheat the cooling water electrically. The heating elements provided for this purpose can be supplied with power from an outside source, a special connection being provided for this purpose.

Protective installations shut down the Diesel engines when the temperature of the cooling water exceeds 85° C, when the water level is too low and when the oil pressure or cooling water pressure drops.

There are in all four fuel tanks with a total capacity of 4.5 m^3.

The compressed air for the brakes is supplied by two compressors each with an output of 800 l per minute at a pressure of 9 atm. The brake equipment was supplied by the Bührle & Co., Machine Tool Manufacturers Oerlikon. The application and release of the brakes can be graduated. The brake cannot be exhausted. There are four brake shoes per axle. The braking ratio is 150 %. An automatic slack adjuster takes up play in the rigging according to the wear of the shoes.

The bogies are of the American type (fig. 8). Their frames are made of hollow sections formed of welded sheet steel. The bogie bolster is of cast steel. The gear ratio of the B.B.C. spring drive is 23 : 72. The traction motors, the toothed gear wheels and the axles are fitted with roller bearings. The suspension consists of both helical and laminated springs, mounted in series.

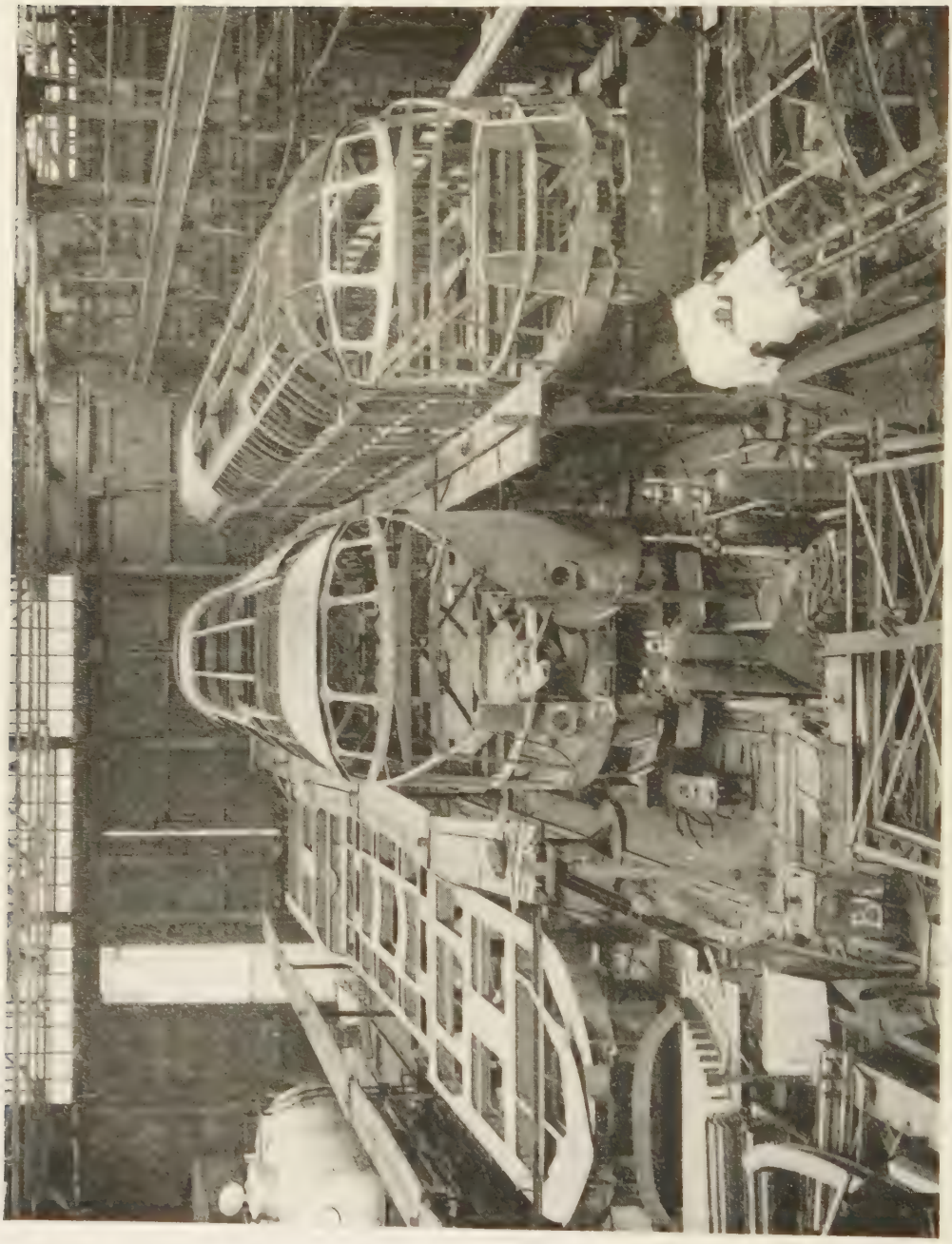

Fig. 6. — Construction of the frame and body.

Fig. 7 — Drive in the driving compartment

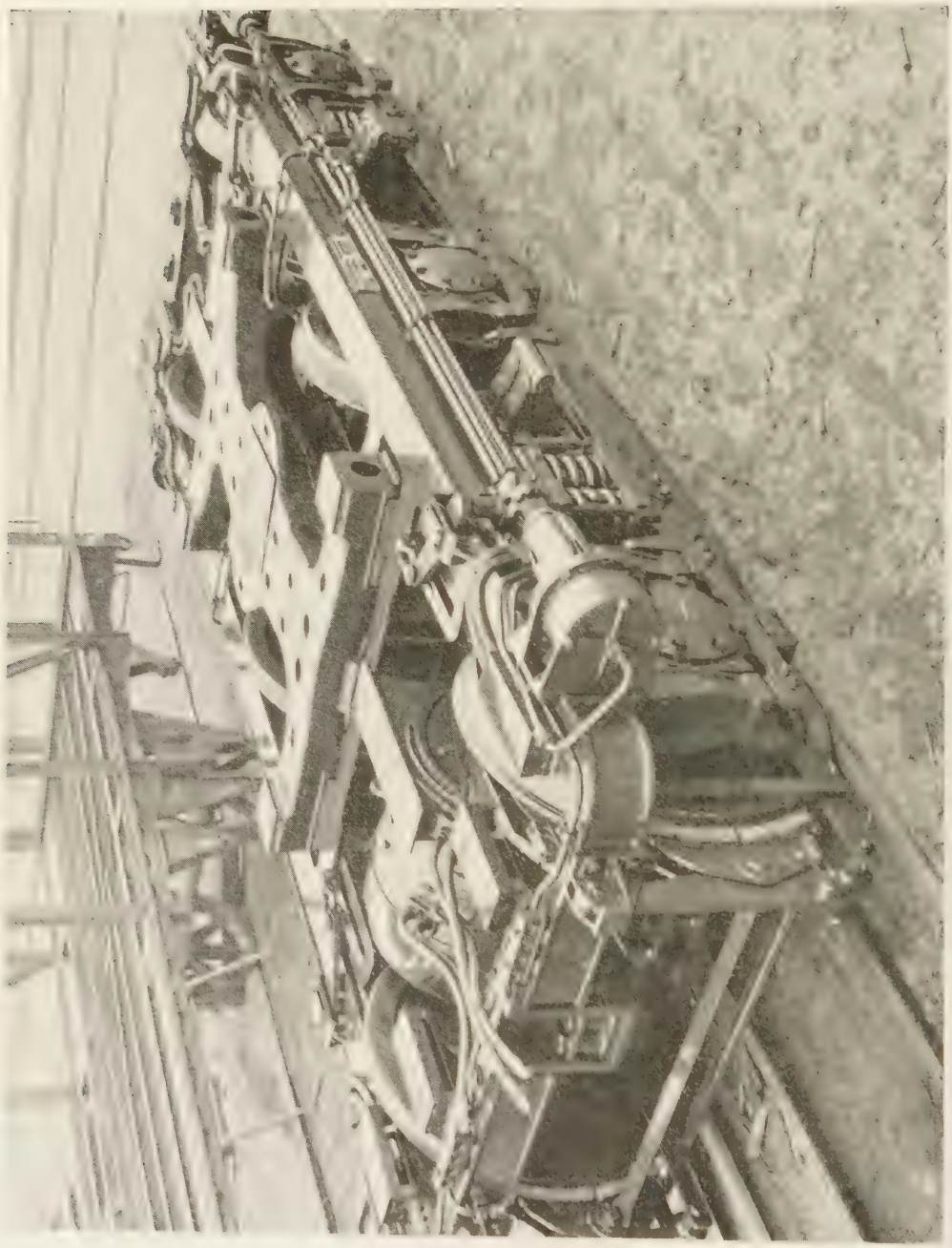

Fig. 8. — Bogie of the motor unit

The maximum speed is 140 km (87.8 miles) h. Trials have shown that on a gradient of 16 ‰, it is possible to attain a speed of 70 km (43 miles)/h from stop in three minutes.

COACHES

The Administrations participating in the operation of the T.E.E. rakes not only wanted to give a service between the main traffic centres of Western Europe, but also to make the journey as comfortable as possible. Particular attention has been paid to the equipment and behaviour during running of the coaches. Seen from the outside, the coaches have a simple, well proportioned

Fig. 9. — Separate compartment.

In order to get as wide availability as possible, and in view of the fact that the time available for construction was limited, only well proved components have been used; it was therefore not possible to introduce any innovations.

Fig. 10. — A corner of the restaurant-car.

line. The interior is restful and pleasant; the colours of the seats harmonise with the soft tones of the walls. The windows have double glazing. Between the panes of safety glass there are venetian blinds easily worked by a lever. The coaches are completely air conditioned, so the windows are fixed and hermetically sealed; there are no draughts. The venetian blinds make it possible to dim the light coming in as required. Each coach has its own air conditioning equipment,

on the Stone system. The air is continually being renewed and the temperature remains constant, which makes the journey pleasant. Each seat consists of an armchair with adjustable seat and back luxuriously upholstered.

ment. The kitchen is equipped with all the necessary equipment — of Swiss manufacture — all working by electricity : grill, fryer, coffee percolator, mixer, whip, etc. The equipment has been designed for serving first class meals, in

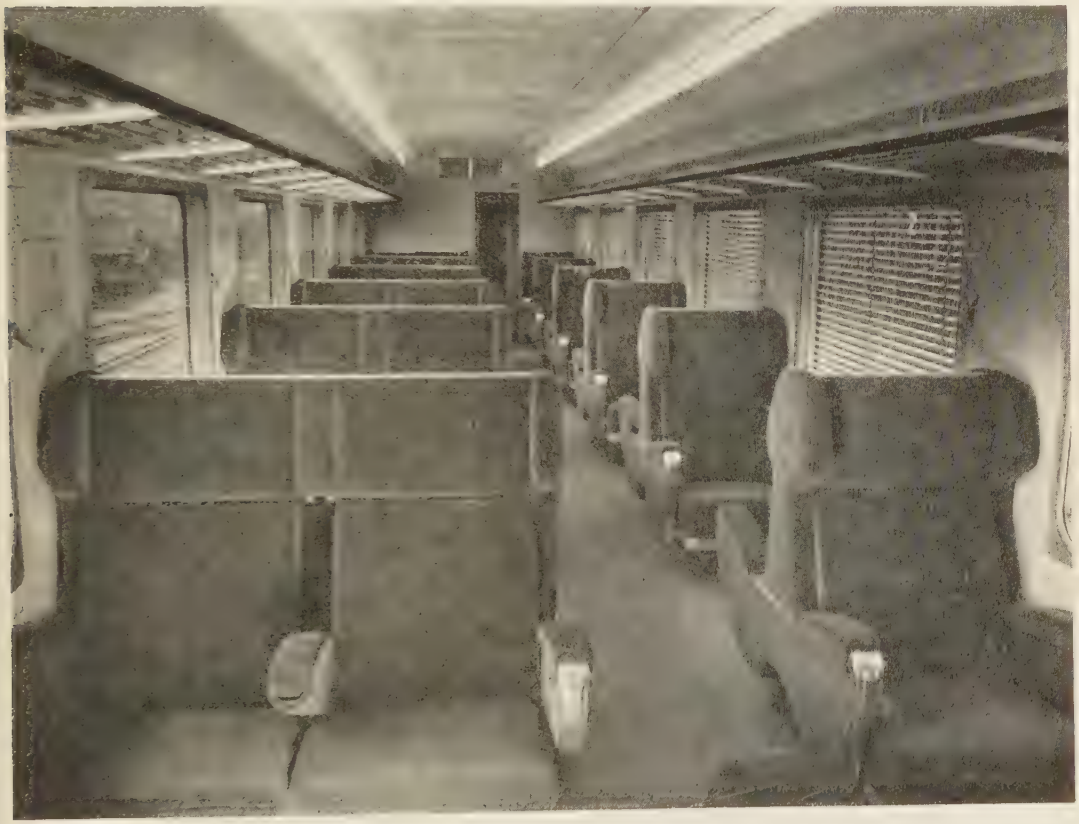

Fig. 11. — Open compartment.

The coach immediately behind the motor unit consists of nine separate compartments each with six seats. The compartments (fig. 9) are 2 100 mm long and 1 925 mm wide. They are modern and pleasant in design. The second coach includes the restaurant compartment the usual time, whatever the number of diners. Large refrigerator cupboards make it possible to keep drink and foodstuffs cold. The restaurant itself (fig. 10) provides 32 seats; in the adjoining compartment, it is also possible to serve another 18 people.

Fig. 12. — Passage between two vehicles.

The last coach, i.e. the third, consists of a large compartment with 42 seats (fig. 11) the aesthetics of which have been very carefully studied. Luggage racks arranged longitudinally make the compartment more spacious. At the end of the coach, equipped as a driving unit, there is a compartment for the driver, and behind this a compartment with a bunk for the train staff.

The steps, entry and interconnecting platforms between the coaches are of spe-

Fig. 13. — Toilet.

cial design. The passages between the coaches (fig. 12) which are arranged at the side are large and hermetically sealed, so that passengers are protected from draughts and dust. There are altogether five toilets (fig. 13) and two large wash-places on practical and uptodate lines. All the passenger compartments are fitted with indirect fluorescent lighting, which gives a pleasant and even light.

The bodies of the coaches are self-supporting, of rigid tubular construction

like the light-weight coaches. In addition, they are heat insulated and soundproofed.

The bogies are of the same type as those used with the C.F.F. light-weight coaches. The body rests on the bogie frame through a bogie bolster suspended on torsion bars. The bogie frame is suspended in its turn by helical springs on the axle boxes; the guiding of the frame, without play, is realised by cylindrical guides with oil shock absorbers.

Trials have proved that these coaches run very well in service. The soundproofing is excellent.

It is proposed to put the five N.S. C.F.F. T.E.E. rakes into service on the Amsterdam-Zurich and Amsterdam-Paris lines. The two Administrations hope that the public will like these trains and travel in comfort in them.

Automation of clerical duties,[1]

by Professor, Dr.-Eng. R.M.M. Oberman.

(*De Ingenieur*, No. 43, October 26, 1956)

Summary.

Automation with the aid of electronically operated data processing systems gives rise to special problems in connection with the processing of data and the subsequent reproduction of the results in a legible form.

Certain types of machines which can be used for this purpose (and the systems in which they can be used) are described here. Also described are the principles applied to the detection and examination of marks such as sorting marks, the use of magnetic tapes and paper, as well as high-peed printing equipments.

1. Introduction.

For many years, one has tried to mechanize, with the aid of punched cards, certain kinds of clerical duties. One punching operation serves to transfer to a punched card data which are available in written or typewritten form on various documents (e.g. invoices, current accounts). The information thus encoded on punched cards, in the form of punched holes, constitutes the basic data for the subsequent operations which, up to a short time ago, did not with this system go much beyond the stage of sorting the cards in accordance with different orders, and of adding up basic data in order to form, on the basis of small groups of data, a final output data in printed form (sometimes also in punched form), e.g. to issue a receipt. At the same time, it was possible to obtain a continuous overall picture of all the operations carried out.

This mechanisation by means of punched cards generally concerns a simple operation carried out by a certain section of an administrative office, an operation less suited for manual work because it entails the identical treatment of a great number of similar data of the same kind. Mechanisation of this kind has the effect of reducing the number of staff required to obtain the same final results. However, there remains the question, which cannot always be answered in the affirmative, whether the total cost of the clerical work has in fact been reduced through this mechanisation by means of punched cards. It is sometimes possible to reduce the costs of clerical work by making use of specific possibilities of the machines and setting up a more efficient administrative organisation.

In the course of the last fifteen years, electronic computers have been developed for the purpose of carrying out scientific calculations. These machines have introduced two new specific possibilities into data processing:

a) a very high speed of data processing: all possible algebraic operations can be carried out within a few micro-seconds;

b) greatly expanded storage facilities for the storing of intermediate as well as final results.

By making use of these facilities it is possible, even when introducing and read-

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(1) Paper read at Delft, on 9th May, 1956, before the Electrotechnical, Mechanical and Shipbuilding Sections of the Royal Dutch Institution of Engineers.

ing off at very high speed small groups of data calling for individual treatment, as is the case with certain specific types of clerical work, to carry out complicated intermediate operations with each of these small groups of data and even, if necessary, to modify the operations in accordance with the results and with directives stored beforehand, so that the equipment can be adapted to changing circumstances. Operations of this kind may for instance be necessary if the machines are employed on cost accounting work. With such modifications, these machines are transferred from the sphere of mechanisation to that of automation.

Such machines, now known as « electronic data processing systems », are also able to assemble data of different kinds, to compare, sort and select them, to modify them and to treat them in such a way that they yield other data required by the office concerned. To mention only one example among many, the Chesapeake and Ohio Railroad (C. & O. R. R.) in the United States, which is comparable in size with the Netherlands Railways, is about to introduce, and is perhaps already using, a single electronic data processing machine for the entire goods traffic of the system. This company owns some 8 000 km of railway lines spread over eight States and one Province of Canada, carrying wagons of this company as well as of other companies.

If a wagon, belonging to the C. & O.R.R. or to any of the other 472 companies, enters the C. & O. R. R. system, or if a wagon takes on a new load anywhere on the system, the basic data are recorded in a standard form by means of a teleprinter which, at the same time, produces a punched tape. The standard formula contains all the information required for the subsequent machine operations.

Every new phase of the transport process is thus being followed up, the information being forwarded, before the departure of the train, both to the station ahead and to the central data processing machine. The operations carried out by this machine permit, practically in one single operation, the issue of invoices to the client and to the other companies, the calculation of the cost price, and the recording of data required for the distribution of the wagons. In the United States, such work is termed « integrated data processing ».

It is not the purpose of these notes to discuss aspects of the organisation of different administrations, nor to state what these might be able to achieve with data processing machines.

2. The conception of data processing systems.

A data processing system does not mean a single machine which would be able to carry out all the possible and necessary operations with the data fed into it. Generally speaking, the system will consist of a group of machines of different types, suited for a number of different purposes, and jointly able to carry out the required operations on the basis of the input data.

Generally, it is possible to distinguish, in a data processing system, the parts shown in figure 1.

The data fed into the machine in typewritten or written form are modified by the input organs so that they can be used, in the subsequent machines, in the form of electric currents. It is sometimes necessary to sort this information in a given order, or even consecutively in different orders, before the information currents can be directed towards the operating organs. The information to be used is transformed, with the aid of the input organs, in such a way that it is presented in coded form which can be read by the operating organ. The latter disposes over one or more stores, which may not all be of the same kind, but which contain, in a permanently recorded form, the instructions or data required for the operation, and which permit the modification of this information in accordance with the result of the operations. This case occurs, for instance, with the management of a shop or with certain banking transactions. With the aid of

the output organ, the result of the operations can be translated, either directly or indirectly, from the coded form used inside the machine into a written form of some kind.

The term « electronic data processing systems » by which these machines are usually known suggests that these machines work mainly by electronic means. This is, however, only true for the central organ

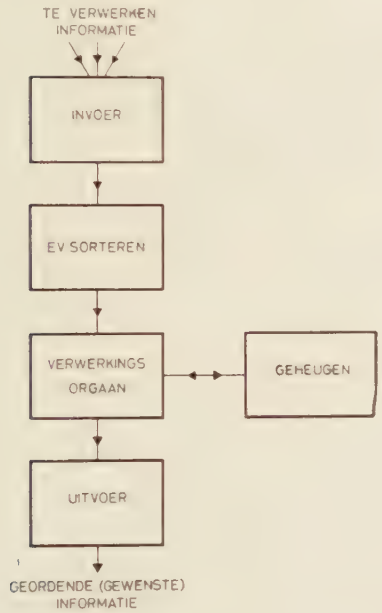


Fig. 1. — Diagram of an electronic data processing machine.

N. B. — Te verwerken informatie = information to be dealt with. — Invoer = entry. — Ev sorteren = sorting (out). — Verwerkingsorgaan = operating organ. — Geheugen = storage device. — Uitvoer = output. — Geordende (gewenste) informatie = requested information.

which carries out the operation, and for the storage device. The input and output organs also comprise non-electronic devices, both for the translation of information into a form suitable for the operation of the machine, and for the subsequent retranslation of the results into a legible form. Such constellation gives rise to a mixture of mechanical and electrotechnical problems which can only be solved through intimate interworking of these two techniques. These are here tied together insolubly because the human brains which produce the information on which the machines must work, and which receive the information produced by the machine as a starting point for further operations, can only act on the strength of information accessible to the senses, i.e. available in some material form.

3. Data input organs.

The table hereafter shows the forms in which input data can be introduced into an electronic data processing system.

The data carriers and the different types of marks listed in Table 1 are, in practice, not yet found in all possible combinations. The problem of introducing information consists mainly in presenting the data in a form suitable for the automatic operations. With many processes which must be tackled by automatic data processing machines, it is possible from the outset to keep the information available in a suitable form. It is for instance possible to make marks with a specially conducting lead pencil (fig. 2) or with a pencil of graphite with magnetic admixture, and thus to recognise a given spot on a card or form. This mark may be detected mechanically by means of a « mark sensing » method (fig. 2 *a*) or else by means of « mark scanning » (fig. 2 *b*) where the electric conductivity or the blackness of the mark is examined.

In general, the mark made by hand is provisionally replaced by a mark made mechanically within narrow tolerances, which may for instance consists of a punched or perforated hole.

Although it would be possible, in principle, to make direct use of the hand-made mark during all the stages of data processing, there are some imperative practical rules militating against such a procedure :

a) for one thing, marks made by hand are often made with little care and may

TABLE I. — **Input of data.**

Data carrier		*Data marks*		
Material	Form	Means	Execution	Recognition
Paper	Cards Tape of soft material	Holes	Punching Perforation	Mechanically Electrically Optically Pneumatically
		Pencil	Line	By conduction Magnetically
		Legible ink	Line Spot	Light reflection Transparency Magnetically
		Fluorescent Ink	Spot	Optically
Magnetic film	Tape		Spot	Magnetically
Photographic film	Miniature tape Card		Spot	Optically

even be faulty. These faults should not be allowed to block precious organs of the machine but must be eliminated as quickly as possible from the operations, and that in a machine which is as inexpensive as possible:

b) the « paper » carrier in the shape of an independent form or card is generally less suitable to pass with the desired speed through the costly high-speed organs of the machine.

With automatic data processing where hand-made marks are employed, it is therefore usual to resort to independent machines for the conversion of the hand-made mark into a machine-made mark. Applications of this kind are, e.g., encountered with the telephone service at Canterbury and in Stockholm and with the population register services in France and in the United States. So far, no marking system has been introduced yet where the public

themselves affix the marks on the cards or forms which must be used by the undertaking.

In a great number of administrations, it will be possible to convert the input data with the aid of suitable personnel operating by hand a number of more or less costly machines. In this connection, tele-

b) reproduction on several tapes of data already recorded on one tape. By sticking the sections of the tapes together, the information is obtained in the desired order. If the information must be sorted in accordance with six-digit numbers, it is reproduced six times, but this may not be possible for certain applications.

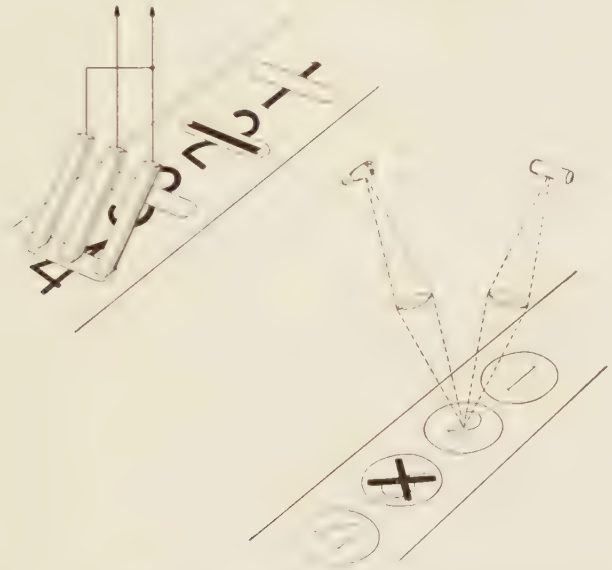


Fig. 2. — Principle of the mark-sensing and of the mark-scanning.

printers might be used if fitted with reperforators which can produce a perforated tape on which the information is recorded in the form of perforated holes. One might also make use of « Justowriter » or « Flexowriter » typewriting machines which produce a perforated tape. For very high speeds magnetic tapes are often used.

In numerous cases, it is necessary to feed the information to the machine in a given sequence. In that case, the information must be sorted in accordance with certain criteria. This sorting might for instance be carried out as follows :

a) individual sorting of the documents to be processed so that the original information is presented in the desired sequence;

The two possibilities of sorting operations are schematically indicated in figures 3 *a* and 3 *b*. The method shown in figure 3 *b* can also be used with magnetic tapes and magnetic drums.

4. Automation of the input organs.

The input organs described in Section 3 are suited for the reading of marks which generally represent information in decimal form. It is desirable to dispose over machines which are able to read off directly the written or printed decimal information and to translate it into a language suitable for the transformation organs.

The problem of reading off figures in a printed, typewritten or even written

form is being investigated in many places. A machine permitting the recognition of printed figures is at present being tested in the San José (California) branch of the Bank of America. Another machine is being tried out in one of the branches of the National City Bank of New York. Development work in this field is being pursued by the Intelligence Machines Research Corps at Arlington (Va).

The recognition of figures is based on the optical perception of specific characters presented at defined places on the form which carries the figures. It is possible to use, in this connection, methods similar to those used in television. Although the automatic recognition of printed figures has made important progress in recent years, these methods have not yet reached such a practical stage that they can be regarded as completely reliable, at least as far as small characters are concerned.

However, in view of the progress in commutation techniques the possibility cannot be ruled out that, in future, even handwritten figures may become legible by some automatic means. This will still take some years. It would seem that the solution of this problem will call for the use of entirely electronic methods.

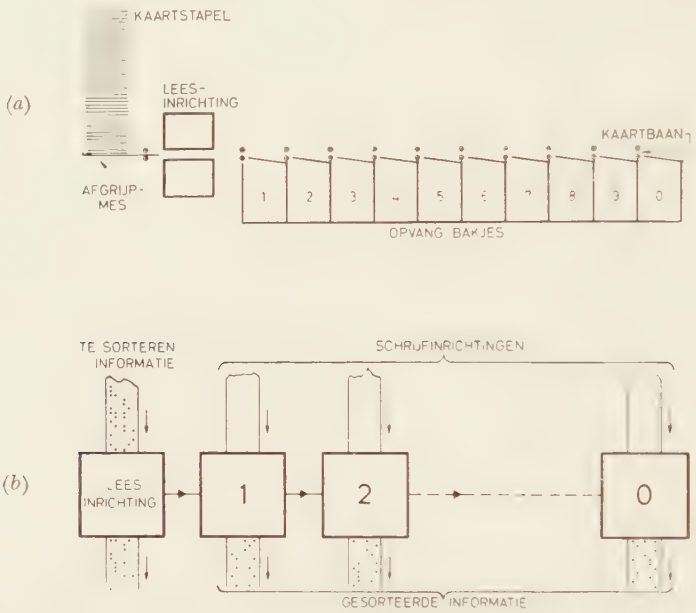


Fig. 3. — Sorting out the information on cards (*a*) and on tapes (*b*).

N. B. — Kaartstapel = stacking of cards. — Afgrijpmes = holders. — Leesinrichting = reading apparatus. — Kaartbaan = card way. — Opvang bakjes = receiving boxes. — Te sorteren informatie = information to be dealt with. — Schrijfinrichtingen = registration device. — Leesinrichting = reading apparatus. — Gesorteerde informatie = information sorted out. — Boven = above. — Onder = under.

5. Output organs.

The possibility of introducing information at high speed with the aid of magnetic tapes, and of processing this information

very rapidly by electronic means and magnetic storage, entails the need for high-speed output organs so that the input speed is matched by an equally high output speed. A magnetic tape can be used if the results are not required in printed form.

In the majority of automatic data processing operations, the results must be available in some printed form, e.g. in the case of wages slips, insurance premiums receipts, banking accounts, etc. It is conceivable that speed of operation and speed of output can be made independent of each other by arranging that the operating organs supply their results in the form of a magnetic tape. This tape can then be introduced into a certain number of tabulating machines which print the results at

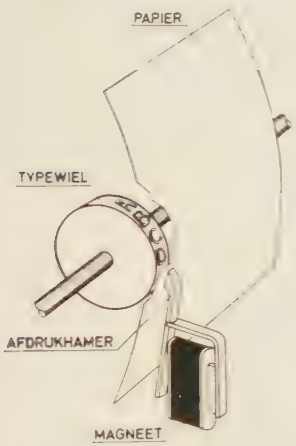


Fig. 4. — High speed printing machine with flying print.

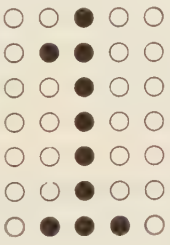


Fig. 5. — Printing head with 35 wires.

N. B. — Typewiel = type wheel. — Afdrukhamer = printing hammer. — Magneet = electromagnet.

a rate of three lines per second. These tabulating machines normally serve as printing machines with mechanized punched card systems. An electronic data processing system can easily supply data at a speed sufficient to keep 4 to 10 tabulators going. This fact is behind the development of printing machines of very high speed, able to print one whole line at a time.

The types of line-printing machines already commercially available represent the outcome of combined mechanical and electrotechnical studies. This has come about in two ways during the last few years.

a) *High-speed line printing machines with permanently rotating type wheels.*

The American Companies Remington Rand and Shepherd have produced machines based on a working principle that has been used in telegraphy for many years, viz., a flying print with the aid of a type wheel which rotates continuously at a constant speed. These machines work at a speed of 10 to 15 lines per second, each line comprising 100 to 130 letters or signs.

The machine consists of a permanently rotating shaft which carries as many type wheels as there are printing characters in each line. All these type wheels are keyed to the shaft in the same angular position (fig. 4).

Facing the shaft are a certain number of sheets of paper sandwiched with carbon paper, and the last sheet, likewise covered by a sheet of carbon paper, faces a row of small hammers which can strike individually under the influence of an equal number of electro-magnets.

The printing of a given letter on a given type wheel is obtained by causing the little hammer to strike at the proper moment when the character concerned is exactly in front of the paper. In order to obtain a clear print in spite of the fact that the wheel is in permanent rotation, the hammer must only be allowed to strike for a very brief moment. In fact, the machines in question produce a very clear print. The electro-magnet actuating the hammer receives a strong current during a limited time with the aid of the electronic equipment. The time must be less than a millisecond, and the power must be about 1 kW. The angular position is verified at the moment when the hammer is actuated so that a faulty print cannot pass unnoticed.

In principle, the construction of machines

of this type is governed by the following problems :

α) the synchronisation of the working of the printer electro-magnets of the different type wheels in respect of the speed and position of these wheels;

β) the exact timing of the energizing impulse of the electro-magnets, especially in view of the possibility of overload which might cause the electro-magnets to burn out;

is limited by the operation of the keys. The pressure on the keys must, of necessity, be fairly strong as it is necessary to make a choice between a certain number of keys. A type wheel admittedly allows the simultaneous printing of a great number of characters on one line, but the speed is limited by the time required to select the character on the circumference of the type wheel.

It is also possible to obtain a print of

TABLE II.

a	++----	q	+++-+-	1	+----+	-	+---++
b	+--++-	r	-+-+--	2	-+---+	?	-+--++
c	-+++--	s	+-+---	3	++---+	:	++--++
d	+--+--	t	----+-	4	--+--+	)	--+-++
e	+-----	u	+++---	5	+-+--+	(	+-+-++
f	+-++--	v	-++++-	6	-++--+	·	-++-++
g	-+-++-	w	++--+-	7	+++--+	'	+++-++
h	--+-+-	x	+-+++-	8	---+-+	"	---+++
i	-++---	y	+-+-+-	9	+--+-+	=	+--+++
j	++-+--	z	+---+-	0	-+-+-+	+	-+-+++
k	++++--		+++++-		++-+-+		++-+++
l	-+--+-		++-++-		--++-+		-'-++++
m	--+++-		--+---		+-++-+		+-+++
n	--++--		-+----		-+++-+		-++++
o	---++-		---+--		++++-+		+++++
p	-++-+-		------		----++		-----+

γ) the feed of several paper tapes of by no means negligible thickness and width which are sometimes required to change their speed abruptly.

In connection with the third remark, it must also be pointed out that machines of this kind may also have a tendency to produce an irregular print as regards the orthogonality of the characters in relation to the line.

b) *Decomposed characters.*

An entirely different printing system is based on the decomposition of the characters. In a typewriter, the printing speed

a letter or figure by decomposing a rectangular surface into 5 × 7 points. This is shown in figure 5. In this way, it is possible to print ten letters per linear inch of line. Such printing machines have been constructed by the International Business Machines Corporation (I. B. M.) and by Burroughs which achieve printing speeds of 33 and 15 lines per second respectively. Figure 6 shows the machine developed by I. B. M., figure 7 the one developed by Burroughs (2).

(2) The photographs have been kindly placed at our disposal by the I. B. M. and Burroughs Companies.

The I. B. M. machine can be used with 2 or 4 of the striking units which are rather expensive, so that the speed of the machine may decrease to 16 or 8 lines per second.

Fig. 6. — I. B. M. high-speed line printing machine.

The rectangle of points arranged as shown in figure 5 is obtained by means of a bundle of 35 thin wires which can be moved on according to the combination selected. Figure 8 shows a series of printing units of a Burroughs machine, while figure 9 shows the design of a printing unit in principle ([3]). The choice of a given printing combination is a problem of conversion or code translation.

The organs which carry out the operations of the automatic data processing machine generally supply their results in a coded form which is as concise as possible. This is necessary in order to keep the operating organs as simple as possible.

The 26 letters, 10 figures and other characters indispensable for reading, a maximum of 64 characters all told, can be translated by a six-moments code such as the one shown in Table II.

In the machine language, every character is represented by a combination of six elements where the elements may either be transmitted consecutively (i.e. one after the other) or in parallel (simultaneously

([3]) « Product Engineering », June, 1955.

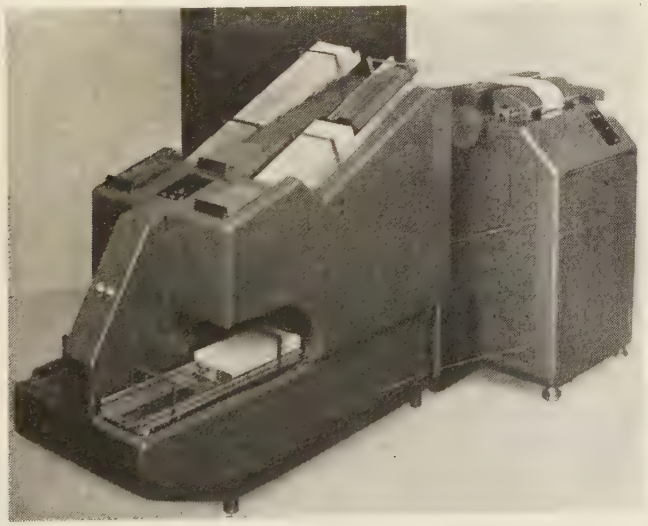


Fig. 7. — Burroughs high-speed printing machine.

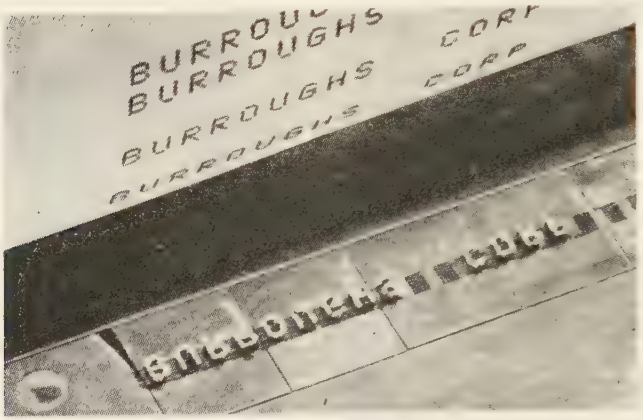


Fig. 8. — Printing unit.

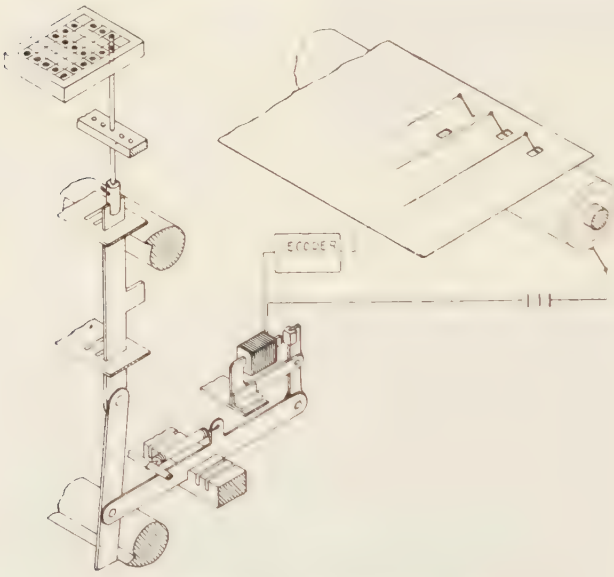


Fig. 9. — Diagram of a printing unit with wires.
N. B. — Decoder = code translator.

on six transmission channels). The translation of this code into those of the printing organs of the machine can take place in two different ways, viz.

α) electronically;

β) electro-mechanically.

To those who study the translation of the code for the first time, this appears to be a difficult problem. But this is not really the case. Coding problems can always be solved by comparatively simple means, even without having to accept a harmful delay in the data processing operations.

Generally, however, it is not possible to be content with a single code translator with this type of printing machine. Figure 10 shows very schematically a diagram of this type of machine. The operating organ, not shown on this illustration, supplies the results in consecutive form. The

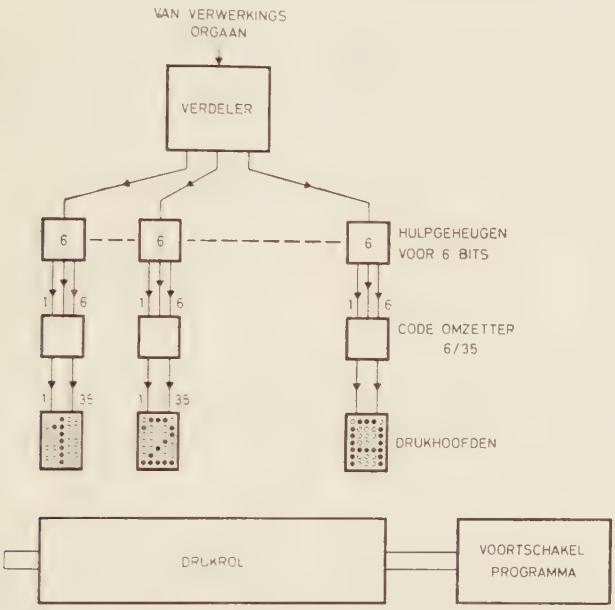


Fig. 10. — Diagram showing schematically a high-speed line printing machine with the translation of the electronic code.

N. B. — Van verwerkingsorgaan = coming from the operating organ. — Verdeler = distributor. — Hulpgeheugen voor zes bits = auxiliary memories for 6 bits. — Code omzetter = code translator. — Drukhoofden = printing heads. — Drukrol = printing cylinder. — Voortschakelprogramma = programme control.

letters and figures to be printed on one line are momentarily stored in a series of auxiliary stores whose number is equal to, or a multiple of, the number of printing organs. Between each of the auxiliary memories and the corresponding printing organs, a code translator is inserted which permits the transition from a six-moments code to a 35-moments code.

Such a code translation can be carried out electronically by means of diodes, transistors, magnetic rings, or similar devices. It is not intended to discuss here the technical details of the commutation used with this kind of equipment.

The encoding can also be carried out mechanically by means of plane or cylindric metal screens with holes. These screens are moved in accordance with the six-pulse code in such a way that, during the printing, only the combination chosen in the 35-wire set can be projected.

The printing organs are aligned in front of the printing cylinder which feeds the paper. During the printing of the results of the operations carried out by the data processing machine, the paper feed is not constant but follows a programme which is either laid down beforehand or is determined by the machine tiself. If it is, for instance, necessary to make out invoices,

wages statements or insurance premium receipts, the different wordings must be printed at places determined beforehand on the paper but varying as between one receipt and another. The high-speed printing machines here discussed are all equipped with programme control by means of a perforated tape so that the desired section of the forms can be obtained.

It is often a difficult puzzle to arrange the forms in such a way that the costly machine can be used in the best possible manner. This is not only a question of the paper feed but also a problem of the programmation of the data processing operations carried out by the machine and of the interworking of the operating organs and the printing machine.

Figure 11 shows an example for premium receipts. The number of printing lines might be reduced from 7 to 5 which would entail a saving in printing time of 25 %.

It must finally be pointed out that the costly organs of the printing machine are not operated directly but by means of a magnetic tape.

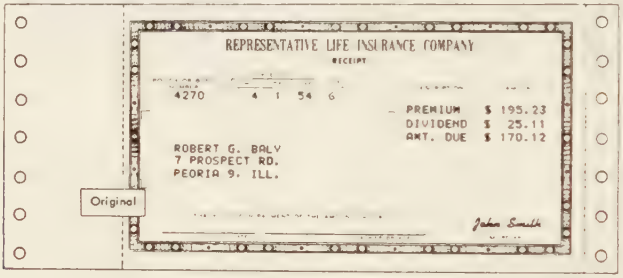


Fig. 11. — Insurance premium receipt printed on a high-speed linear machine.

6. Electronic output organs.

The output organs described in Section 5 have now reached the stage of commercial production. It is at this point of the data processing machines that electronics and mechanical operations must be combined in order to obtain this result.

Printing machine research workers are of the opinion that the speed is inadequate. The principle of mechanical printing on paper by means of point printers appears to be unsuitable for very high outputs. There are however, other principles in existence which may lead to much higher printing speeds. Only one of them may here be referred to.

The Radio Corporation of America has developed a system based on the use of a special image tube, with a screen on which the desired letters and figures are traced. This screen is photographed. The maximum speed is governed by the possibilities of lighting up the screen of the cathodic tube, and of photographing it. Figure 12 shows a functional drawing of the electronic part of this printing device.

A screen perforated by holes which are arranged with precision to reproduce the contours of the desired letters and numerals is illuminated by a beam of light. The beam of light which comprises all the letters and numerals which it is possible to print, falls on the photo-cathode of a special image tube, giving rise to an electronic flux which likewise comprises all the characters which it is possible to reproduce.

This electronic flux is controlled, i.e. diverted with the aid of the deviation selection winding. Through this winding flows a current of such a kind that only the character to be reproduced presents itself to the selection diaphragm. The latter is only just able to pass the electronic flux which corresponds to a single character

The electronic flux now penetrates to that part of the tube which is under the influence of a second winding, designed to direct the beam towards a precise spot of the image screen so that the characters (letters and numerals) to be reproduced are arranged as a line.

tography. This conception is however not accurate. The printing machines discussed comprised parts which are mainly electronic or mechanical. Such a division into different techniques is no longer possible with the last-mentioned printing process which is rather a combination of complic-

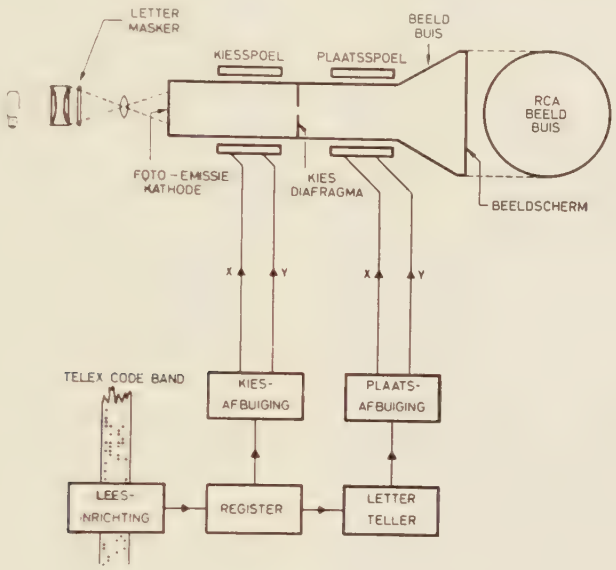


Fig. 12. — Electronic printing machine.

N. B. — Letter masker = type screen. — Beeldbuis = image tube. — Kiesspoel = selection winding. — Plaatsspoel = deviation selection winding. — Foto-emissie kathode = photo-cathodic emission. — Kiesdiafragma = selection diaphragm. — Beeldschern = screen. — R. C. A. beeldbuis = R. C. A. image tube. — Telex code band = telex code tape. — Kiesafbuiging = changing selector. — Plaatsafbuiging = deflection of position. — Leesinrichting = reading device. — Register = recording device. — Letterteller = letter recorder.

The experimental machine of the Radio Corporation of America is controlled by a perforated tape of the type normally used for teleprinters, which is read off photoelectrically in order to attain a high speed. With the aid of simple encoding devices, it is possible to obtain a selection of letters, whilst a counting device enables the beam to be directed so as to form lines.

On the face of it, the printing problem appears to have been transformed into an electronical problem and a problem of photated electronic, mechanical, physical and programmation techniques. The results can only be obtained by the integration of all these techniques. Such an integration can also be found in other spheres.

Let us conclude by pointing out that such an integration is indispensable if the best possible result is to be obtained. There is reason for misgivings that the teaching of these techniques may lag behind because the boundary lines between these different spheres become blurred.

[656 .25 (47)]

Cab signalling equipment with speed control.

(*Deutsche Eisenbahntechnik*, No. 11, November 1956.)

The Railway Technical Research Institute of the U. S. S. R. (Union of Soviet Socialist Republics) has perfected a locomotive cab signalling equipment with speed control, details of which have recently been published (1). It will be useful no doubt for German specialists to know the lines followed in the U. S. S. R. to perfect the continuous control of the running of the trains, the more so as in the Democratic German Republic, steps are also in hand to introduce such equipment.

With the cab signalling equipment in use up to now on the U. S. S. R. pressure on a vigilance button cuts out the automatic braking. As provision is being made to raise the speed over the U. S. S. R. lines, it was considered useful to complete this arrangement by adding an automatic control of the speed. In the completed arrangement, the automatic brake not only is released by predetermined modification of the signal aspect if the vigilance button has not been depressed but it is made a function of the observation of the speeds laid down. Consequently, there are maximum speeds corresponding to the cab signals which cannot be exceeded without causing an application of the automatic brake. The control acts on the following maximum speeds (see fig. 1) :

yellow cab signal between green and yellow track signals : 70 km (43 miles) h;

yellow/red cab signal between yellow and red track signals : 40 km (24 miles) h;

red cab signal, after passing of the red track signal : 15 km (9 miles) h (2).

(1) *Railway Technics*, Moscow, T. 15 (1956), No. 3.

(2) The U.S.S.R. signal code authorises goods trains of a specified load to pass without stopping line signals at red if they are located on rising gradients and in addition have a blue light known as « conditional permissive ». All other trains can pass the red signal after having as required by the U.S.S.R. Technical operating rules made a stop of 2 minutes before the signal.

This system of speed control enables the maximum authorised speeds to be controlled when the stop signal shows green as well as other speeds.

In addition, provision is made to control the speed over station lines with non coded track current

1. When the home signal shows a green light, meaning passage, the train can run over the non coded station lines at the maximum speed authorised.

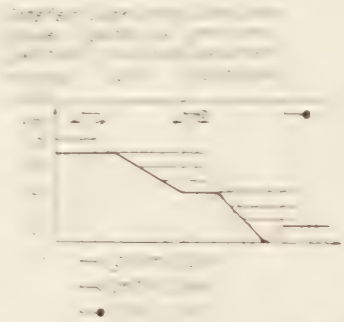


Fig. 1. — Example for the control of the speed.

N. B. — Code f. ein grunes Lokfuhrerstandssignal = code for a cab signal at green — Code fur ein gelbes... = code for a cab signal at yellow. — Code für ein gelb-rotes... = code for a cab signal at yellow-red — Grunes Signal = green signal. — Gelbes Signal = yellow signal. — Rotes Signal = red signal.

2. If the home signal shows a yellow light, requiring the train to stop at the departure signal, the equipment ensures over the non coded station lines the reduction of the speed to 40 km h. But once the speed is reduced to 40 km h, the speed control is cut out and allows the speed to be increased again provided the departure signal goes to « line clear » whilst running over the station lines.

When the limit of the controlled speed is exceeded the driver receives a special luminous signal together with an acoustic signal. The driver must then make a service brake application and reduce speed

according to the indication of the cab signal. Should he not do so in 9 to 10 sec the train automatically brakes. The automatic braking also comes into action should there have been premature release of the brake when the prescribed speed had not been attained.

Provision is made that the automatic braking when passing a stop signal which has been released by being passed at over 15 km/h cannot be cancelled by subsequent action of the driver, for example, by reducing speed. This is intended to increase the respect for the stop signal. At the same time it remains possible to pass the permissive condition stop signal at 15 km/h.

As regards goods trains provision is made to prevent the automatic braking at the yellow line signal released by passing it at over 50 km (31 miles) h being annuled by a subsequent speed reduction. This measure should incites the driver to slow down immediately before the yellow signal so that it can be passed at the prescribed speed of 40 km h, in fact at 50 km/h the service brake application would not be enough to stop the train before the stop signal.

To deal with train movements approaching a temporary signal an auxiliary button with a lead seal is provided in the cab. After operating this button the limitation of speed to 15 km/h beyond the temporary signal is cancelled but only provided the speed had been reduced to 15 km/h before reaching the signal.

The speed indicator is coupled to a recorder recording not only the speed but also the sections over which the cab signal showed a yellow or yellow/red light in order to be able to determine later on the cause of an automatic brake application or of a speed reduction.

If driven in accordance with the indications of the signals, there is no brake application. In figure 1, the control of the speed is shown diagrammatically as an example. The thick line shows the normal prescribed running of a train. It shows that beyond the green signal the driver is not obliged to reduce immediately the speed if it is already 70 km/h or less. But as the train approaches a yellow signal, the driver to obey the rules reduces the speed after a certain time so that when in line with this signal it does not exceed 40 km/h. In this case the automatic brake action does not take place. Continuing to run at 40 km/h the driver is required by the rules to slow down again after a time to bring his train to a stop before the signal. After standing 2 min, the train can pass the stop signal at 15 km/h without being prevented from doing so by an automatic brake application (3). The trains represented by a thin line are special runs with speeds in excess of those authorised. The diagram shows that if the speed is exceeded when passing the three signals represented and if the driver has not started to brake in t seconds, an automatic application of the brake is made.

The speed control described represents an improvement in cab signalling with automatic braking as used in the U. S. S. R. It involved some modification in construction in the installation for deciphering the coded track circuit currents, the addition to the speed indicator of a recorder with contacts controlling the speed by closing and the fitting of a control relay for looking after the reduction of pressure in the train pipe.

The tests demonstrated the practical value of the new cab signalling equipment with automatic braking. The Railway Technical Research of the Union intends nonetheless to improve the new installation in order to exclude the possibility of a train arriving at a stop signal at a speed exceeding 15 km/h, which could occur with the installation described. It is supposed that it is a question of a control of speed as a function of distance which also corresponds with the orientation of the investigation in hand in the Democratic German Republic.

(3) As is known German rules allow the run to be continued without reduction of speed as far as the advanced signal but they never allow a stop signal to be passed at danger without special authority.

[656 .212 .5 & 656 .254]

Wireless remote control of an electric hump locomotive,

by Doctor-Engineer, Heinz WEIDLICH.

(*Signal und Draht*, No. 9, September 1956.)

A. — Introduction.

The present article describes a trial installation which permits the remote control by the hump master of an electric locomotive used for humping operation. This wireless remote control installation has been developed in close collaboration between the Siemens Company and the German Federal Railways.

B. — Summary description of the working method of the installation.

With this installation, the hump master is able to take a direct influence on the controls of the electric locomotive. He sets up the orders for direction of running, movement and braking on a control desk. Apart from the neutral positions, he has available, for this purpose, five forward power notches and three braking notches. The orders are transmitted to the installation on the locomotive within the shortest possible time. But before they are interpreted and transmitted to the locomotive controls, their correctness is automatically checked. Moreover, the receipt of the order by the locomotive is acknowledged to the control post.

In addition, the locomotive transmits certain messages to the hump master, thus keeping him permanently informed about the movements of the locomotive and the condition of the remote control apparatus. These communications are indicated on the control desk.

Orders and messages are transmitted by means of impulse telegrams which modulate a low frequency sound above the audio frequency band. These sound impulses are then transmitted by radio. Because of the high position of these sound impulses, a telephone conversation between the hump master and the locomotive driver can take place simultaneously over the same radio channel.

For safety reasons, this sound used for the transmission of the impulse telegrams is kept going as a continuous sound in both directions of the wireless communication channel whenever there is no transmission of orders or messages. If any of these two sounds, termed « pilot notes », fails to get through — which may happen in the case of a failure of the radio or wireless telegraphy sets — the emergency brake of the locomotive is applied and the hump master's control desk receives a « trouble » indication. In this condition, the remote control system is out of action until the trouble is remedied. During the transmission of orders or messages, the impulse telegrams themselves are checked. If they are not absolutely correct, they are automatically repeated. After several erroneous repetitions, the emergency brake will likewise be applied and the trouble indication displayed.

C. — Description of the wireless remote control installations.

The complete installation consists of a stationary part and a vehicle-mounted part (fig. 1). Both parts comprise a wireless set, a wireless telegraphy set, and remote control set. In the stationary part of the installation, the remote control set

is linked with the control desk. In the vehicle-mounted part, the receiver of the remote control set is directly connected with the control of the traction motors and brakes of the locomotive, by means

1. *Stationary part of the installations.*

a) *Wireless set.*

The design of the stationary wireless installation is similar to that of the

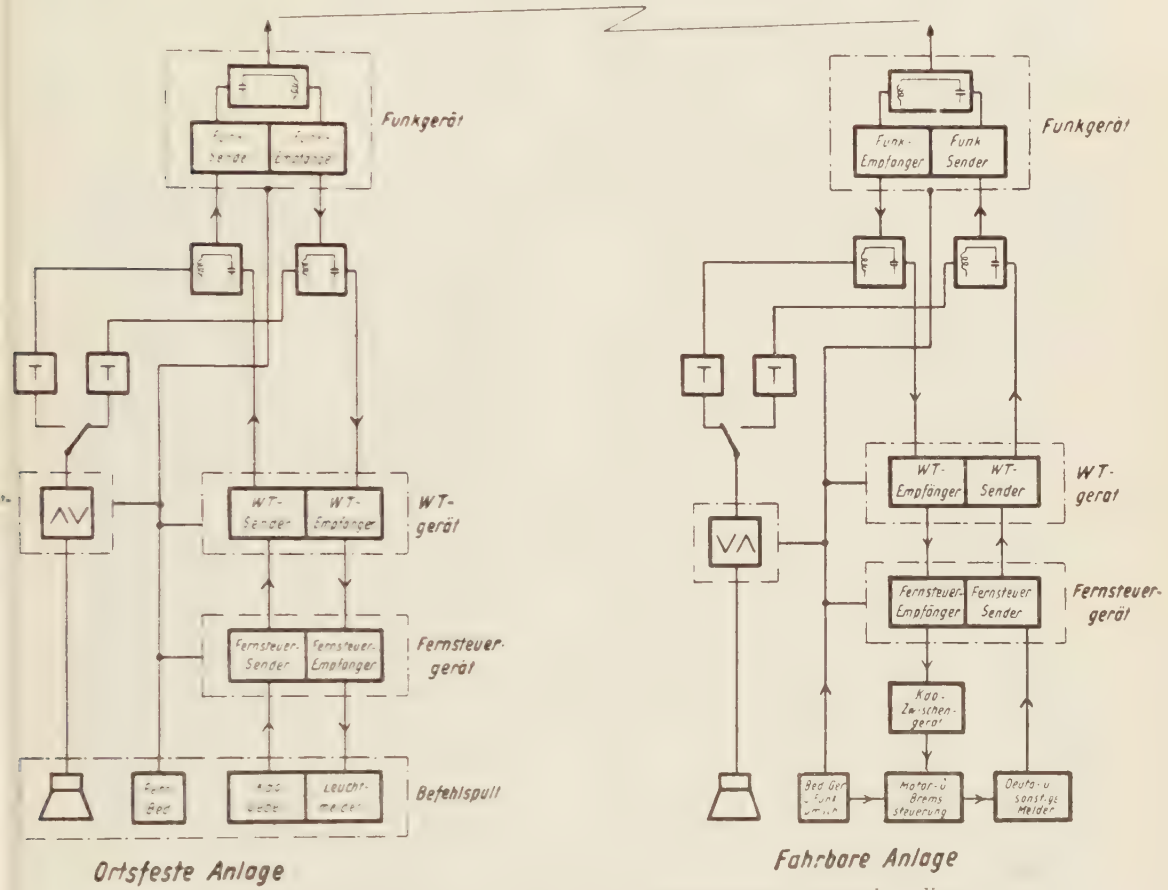


Fig. 1. — Wireless remote control installation. Comprehensive connection diagram.

N. B. — Ortsfeste Anlage = stationary installation. — Fahrbare Anlage = vehicle-mounted installation. — Funkgerat = wireless set. — Sender = transmitter. — Empfänger = receiver. — WT Gerät = wireless telegraphy set. — Fernsteuergerät = remote control set. — Sprechverst. = radio telephony. — Befehlspult = control desk. — Fern. Bed. = remote control. — Kdo Geber = order transmitter. — Leuchtmelder = illuminated indicators. — Kdo Zwischengerat = intermediary control gear. — Bed. Ger. u. Funkumsch. = control gear and wireless commutator switch. — Motor- und Bremssteuerung = control of motors and brakes. — Deuta- u. sonstige Melder = Deuta and other indicating devices.

of the intermediate automatic control. The transmitter of the remote control set is controlled by the different message transmitters.

Siemens 536 Y 313 wireless set. It works in the range of frequencies normally used by the German Federal Railways for their wireless intercommunication systems in

marshalling yards, viz. in the 4 m band. The stationary installation is exclusively used for the purpose of remote control and the radio telephony traffic associated with it. It is therefore confined to duplex operation. A different installation is available for the radio telephony system normally used in marshalling yards. The inlet side of the *transmitter* consists of a low-frequency amplifier which, apart from the amplification, ensures the regulation and limitation of the low frequency voltage received. This may either be the speech voltage or the modulation voltage originating from a wireless telegraphy set, which is applied to the radio channel either in the form of a continuous sound, or in the form of telegram impulses. The maximum modulation is 15 kHz per second. Distortion in adjacent bands is minimized by special measures. A heated quartz oscillator equipped with thermostat control produces a fundamental frequency of about 2 MHz which is phase-modulated in the modulator by the modulation frequency applied. The modulator stage is followed by a five-step multiplier stage with band pass coupling. The last doubler stage also serves as exciter stage for the subsequent power amplifier which is normally capable of supplying a high frequency transmission power of about 40 W but which, in this special case, has been reduced to a power of 3 W. The *wireless receiver* has a four-circuit ultra-short-wave inlet for a frequency range or 1 MHz, its sensitivity being 1 micro volt.

The first thermostat heated quartz oscillator produces the fundamental frequency which serves to obtain the first heterodyne frequency after two doubler stages with band pass coupling. The first frequency-changer valve is followed by a four-circuit intermediate frequency band filter with high damping effect on the specular and subsidiary waves of the second intermediate frequency. A second frequency-changer stage is followed by multi-circuit band passes and several intensifier stages for the second intermediate frequency, as well as the limiter and demodulator. The final push-pull stage can supply a response of 3 W. The adjustable noise suppressor can be disconnected.

Radio transmitter and receiver are connected to the aerial through an aerial change-over switch. The stationary parts of the wireless equipment are housed in a separate telecommunications room (fig. 2).

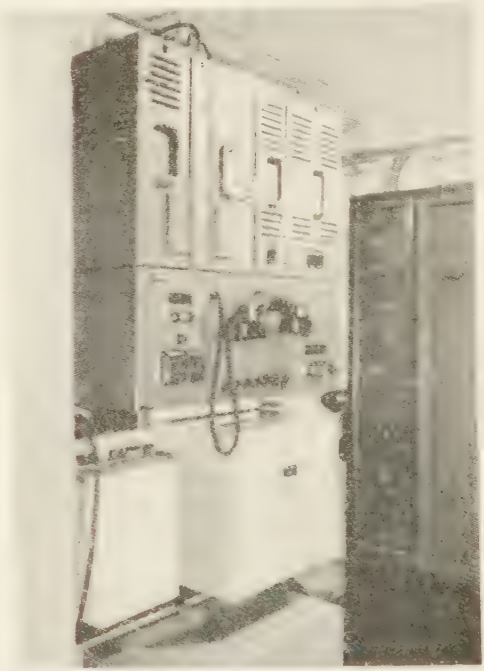


Fig. 2. Stationary installation with wireless set, wireless telegraphy set and amplifier.

The stationary aerial consists of a Siemens omnidirectional wide-band antenna for the 4 m band, installed on the same support as the aerial of the marshalling yard intercommunications system, 3 m below the latter. The power gain of this aerial, which is designed in accordance with the co-linear principle and represents a much shortened whole-wave dipole, amounts to 1.3.

b) *Wireless telegraphy set.*

The single-channel wireless telegraphy set is a set of normal type. The transmitter produces a sound of 2 940 cycles. This sound either appears as a continuous note controlling the wireless channel, or is chopped, during the transmission of orders, in accordance with the impulse telegrams sent out by the remote control set. The transmission level is adapted to the special case. The receiver of the wireless telegraphy set receives the sound impulses from the installation on the locomotive which are transmitted to it by the wireless receiver, and converts them into corresponding impulse telegrams for transmission to the receiver of the remote-control set. During the transmission of the continuous note, only one contact is made in the receiver of the remote-control set.

The wireless telegraphy set is housed on the right below the stationary radio installation (fig. 2).

c) *Remote control set.*

The remote control set serves to set up the impulse telegrams and to interpret the messages coming from the locomotive. To each impulse telegram corresponds a certain order. For each of them, eleven signals are required, viz. six impulses and five intervals. Only nine out of these eleven signals are used for the setting up of the order whilst the two others serve to form the starting and concluding impulse, respectively (fig. 3). During the setting up of the order, the duration of two out of the nine signals is prolonged by twice the duration of a normal signal. The position of the two prolonged signals within the nine signals can be varied at will so that $(9/2) = 36$ different orders can be transmitted. As the normal duration of a signal is 30 ms, the prolonged signals as well as those indicating the beginning and end of a message have a duration of $3 \times 30 = 90$ ms, and the total transmission of an order takes $7 \times 30 + 4 \times 90 = 210 + 360 = 570$ ms.

The impulse telegrams are formed by the interworking of two impulse generator relays and a rotary selector with eleven parts. One of the relays produces the impulses, the other the intervals of the impulse telegram. During this process, the two relays de-energize each other. The length of the de-energizing time is governed not only by the inductance of the relays but also by the magnitude of the resistance in the de-energizing circuit. By modifying this resistance, it is therefore possible to determine the de-energizing time of the relay and, in consequence, the duration of the impulses and intervals. The connection and disconnection of the resistances is partly governed by the rotary

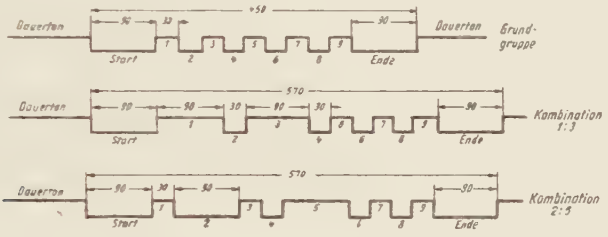


Fig. 3. — Impulse telegrams.

N. B. — Dauerton = pilot note. — Grundgruppe = fundamental group. — Start = commencement. — Ende = end. — Kombination = combination.

selector which, during the transmission of [illegible] order, is moved on step by step by the [illegible] of the impulse relays. For a [illegible] may be varied in two given [illegible] of the [illegible] selector so that [illegible] the long impulses and the long interval [illegible] the prescribed position in the [illegible] telegram. If several orders are [illegible] set up at the control desk, [illegible] corresponding telegrams are always [illegible] in the following sequence [illegible] in the closing direction, [illegible] As the impulse relay short-circuits the sound produced in the wireless [illegible] set, the impulses of the impulse [illegible] are transmitted as sound intervals.

The [illegible] of the remote control set [illegible] the impulse telegram of the wireless telegraphy set in the form of contact [illegible] effected. But the relay [illegible] at the receiver only comes into [illegible] at the first interruption of the [illegible] is at least three times as long as a [illegible] impulse. The set will therefore [illegible] respond to a single disturbance [illegible] sound transmission. The different impulses cause the receiver selector to turn [illegible] by step so that it works in synchronism with the rotary selector of the [illegible]. The position of the long impulses and long intervals which determine the contents of the telegram is [illegible] by subsequent relays. The [illegible] time of the impulse relay con[illegible] and that of the interval relay, [illegible] such that these relays cannot react to a signal of normal duration but only to the [illegible] signals. As we shall explain in [illegible] presently, the impulse telegram coming from the locomotive has a [illegible] which differs slightly from that of the messages in the opposite direction as they, at the same time, contain all the information to be supplied by the locomotive whilst the messages sent to the locomotive exclusively consist of one order at the time. In the course of a selector revolution it is therefore possible for several control relays to be brought into action. But the indicator at the control desk will only appear if, after the termination of the impulse telegram, there has been an automatic verification whether the number of impulses was correct, and whether the selection characteristics introduced had the prescribed length. The control relay concerned remains energized under the influence of a holding circuit. If, on the arrival of a new impulse telegram, a message has already been received which is not contained in the new telegram, the holding circuit of the corresponding relay is interrupted and the earlier indication becomes extinct. Thus, the entire indication is verified whenever a new message or acknowledgment is received. The acknowledgment of the delivery of an order acts on the transmitter side of the remote control set so that the repetition of the impulse telegram constituting the order is interrupted.

The trouble indication on the stationary part of the remote control set appears when

[illegible] the impulse transmitter does not start up correctly;

[illegible] impulse telegram (order) sent out to the locomotive has not been

Fig. 1 — Stationary remote control set.

acknowledged by the latter in spite of several repetitions (whose number can be adjusted from 1 to 5 times)

c) an incoming message could not be interpreted because it was defective

d) a fuse of the remote control set has blown.

In the cases of trouble listed under *b*) and *c*) above, not only does the trouble indicator appear at the control desk but

push-buttons. Moreover, the control desk is equipped with a microphone/loud-speaker set

The rotary switch labelled « Richtung » (= « direction ») permits the choice of the direction of running. The installation is so arranged that, in the « V » (= « forward ») position, No. 1 Cab of the electric locomotive is leading whilst in the « R » (= « reverse ») position, No. 2 Cab of the locomotive is leading

Fig. 5. — [illegible]

The German [illegible] are explained in the article

the locomotive is also brought to a standstill by the application of the emergency brake, through the interruption of the pilot note.

The remote control set is likewise installed in the telecommunications room, near the radio and wireless telegraphy [illegible] (fig. 4

d) *Control desk*

As can be seen from figure 5 [illegible] control panel contains five rotary switches, eight illuminated indicators, and three

The switch labelled « Fahren » (= « run[illegible] », permits the use of the power notches 0 - 1 - 2 - 3 - 4 - 5, whilst the [illegible] labelled « Bremsen » (= « brak[illegible]g ») permits the use of the braking notches 0 - 1 - 2 - 3. It is possible for the locomotive to start with the brakes on on notches 1 or 2. In brake notch 3 however all the power notches are automatically disconnected.

The fourth switch serves to switch in the [illegible] installation from the control [illegible]. In the « Vorheizen » (= « preheat

ing ») position, the radio valves of the wireless set are being heated, and the wireless telegraphy set and remote-control set are switched in. After a pre-heating time of about 10 min. the installation is ready for operation when the switch is turned to the « Fernsteuerung » (= « Remote Control ») position, subject to the receipt of the acknowledgements « Station funkbereit (= « Control post ready for wireless operation ») and « Lok Funkbereit » (= « Locomotive ready for wireless operation »).

The last switch on the right (« Lautstärke ») serves to adjust the sound volume of the loudspeaker.

The indicator on the right « Station funkbereit » (= « Control post ready for wireless operation ») is illuminated when the stationary apparatus has been switched in from the control panel for remote control operations. If, at this stage, the appropriate switch of the radio set switchboard has been set for « Local operation », e.g. for testing purposes, the indication « Funkgerät auf Ortsbetrieb » (= « Wireless set in local operation ») is illuminated in red on a white background. In this position, the installation can no longer be switched out or in at the control panel.

The indicator on the left, « Lok funkbereit » (= « Locomotive ready for wireless operation »), shows up if the pilot note transmitted over the radio channel is received both on the locomotive and, in the opposite direction, at the control post so that reliable radio transmission is ensured. The two indications « Station funkbereit » (= « Control post ready for wireless operation ») and « Lok funkbereit » (= « Locomotive ready for wireless operation ») must therefore remain illuminated during the whole period of remote control operation as their failure serves to indicate any interruption in the transmission channel.

The indication « Motoren eingeschaltet » (= « Motors switched in ») signifies that one of the five power notches of the locomotive has been switched in. This indication will therefore appear as soon as the controller has passed from position 0 to position 1. Soon after the indication « Motors switched in » has been received, the indication « Lok fährt » (= « Locomotive running ») must be received. If this is not the case, the motors are automatically switched off for safety reasons. With heavier trains, the indication « Locomotive running » is obtained by switching over to higher power notches.

If the train moves in the direction opposite to the running direction selected at the direction switch, a red signal « Lok rollt in Gengenrichtung » (= « Locomotive moving in wrong direction ») is displayed, indicating to the operator that he must apply the brakes immediately.

The signal « Störung Impulsgeber » (= « Trouble, impulse transmitter ») appears either if the impulse transmitter of the remote control set does not start up properly or if, in spite of several repetitions, an order has not been acknowledged, or if an incoming message has been defective.

If orders are repeated several times before they are acknowledged, this signal is only illuminated for a brief moment. If the acknowledgement does not come through at all, a red signal « Störung » (= « Trouble ») appears additionally. The trouble indicator also appears if the radio transmission channel is interrupted, or if there is a failure of the industrial current supply. As already mentioned, the trouble indication is automatically accompanied by an emergency application of the brake.

The control panel has, in addition, three push-buttons marked « Sprechen » (= « Speech »), « Prüfen » (= « Testing »), and Löschen » (= « Cancellation »). The « Speech » button must be pressed if the microphone/loudspeaker set at the control desk is to be used as a microphone. When the button is not pressed, the set works as a loudspeaker. When the « Testing » button is pressed,

all the illuminated signals appear at the same time, so that the proper working of all the lights can be checked. The « Cancellation » button serves to cut out the buzzer which sounds whenever a red signal is displayed (« Locomotive moving in wrong direction », « Trouble », « Trouble, impulse transmitter »). In this case, however, the optical indication remains.

The control desk is connected with the remainder of the installation by means of a 30-point plug.

2. *Vehicle mounted part of the installations.*

a) *Wireless set.*

The installation is similar to the vehicle-mounted wireless installation 516 Y 333 developed by Siemens & Halske. Like the stationary installation, the vehicle mounted installation works on the 4 m band. It is designed to permit duplex operation on one pair of frequencies and alternate two-way operation on two frequencies. Duplex operation is used for remote control, and alternate two-way operation for the radio-telephony system of the type normally used in marshalling yards. In contrast to the stationary installation which serves for remote control operation only, the vehicle-mounted installation is thus used both for remote control and for the normal radio-telephony system.

The phase modulated *transmitter* has, at its inlet, a low-frequency amplifier which amplifies, regulates and limits the audio voltage coming from the microphone or the sound transmitted by the wireless telegraphy set in such a way that, on the one hand, the transmitter is as well modulated as possible for normal sound and speech amplitudes and that, on the other hand, the momentary modulation is limited to 15 kHz per second. This low frequency amplifier therefore contains also a limiting stage, apart from the amplification stages, which are coupled with each other by means of control potentials in such a way that the distortion factor of the transmitter modulation remains constantly small at medium and strong speech and sound volumes so that the transmission of speech and sound is not distorted even with high sound volumes. Another low frequency band limitation above 3 kHz eliminates a great part of the disturbances in adjacent bands, which might otherwise be caused by the formation of harmonics during the limitation.

A quartz controlled oscillator produces the fundamental frequency of the carrier wave of the transmitter. This frequency is introduced to the modulator stage where the low frequency phase modulation takes place. There follows a five-stage multiplier which ensures a strong damping of harmonics and parasites. The last stage also serves as exciter for the power amplifier that follows. The output power of this transmitter normally amounts to 20 W but has been reduced, in this special case, to 3 W.

The *receiver* works with double frequency change. As the remote control works with duplex operation, the receiver frequency is 9.8 MHz higher than that of the vehicle-mounted transmitter.

If the installation is to work in conjunction with the radio-telephony system it is switched over to alternate two-way operation so that transmitter and receiver can work on the same frequency. Owing to a good selectivity of the intermediate frequency, it is possible to adhere to the required inter-channel interval of 50 kHz. The maximum modulation is 15 kHz.

The high-frequency inlet of the receiver consists of a four-circuit ultra-short-wave part of 1 MHz band width having two valves with earthed grid connection so that a sensitivity of 0.5 microvolt is obtained.

The quartz frequency produced in the first oscillator is introduced to two doubler stages where the heterodyne voltage for the first intermediate frequency is obtained. The band pass coupling of the doubler stages has a strong damping effect on the parasites.

The heterodyne frequency is taken,

together with the inlet frequency, to the grid of the first frequency changing valve. The intermediate frequency thus obtained is taken to a four-circuit intermediate frequency band filter. The frequency of the second quartz oscillator is mixed with the first intermediate frequency so that a second intermediate frequency is obtained. There now follow several highly selective amplifications of the second intermediate frequency, the limiting stage and the detector stage. The last low frequency amplification stage consists of a system of push-pull pentodes capable of supplying a speech power of 3 W. The receiver is also fitted with an adjustable noise suppressor.

The vehicle-mounted installation also comprises an *aerial switch* destined to separate the transmitter and receiver frequencies, with an attenuation of 0.15 Neper in the band pass width and more than 4.5 N in the suppression ranges, as well as a *direct-current converter*. The latter produces the plate and grid voltages for

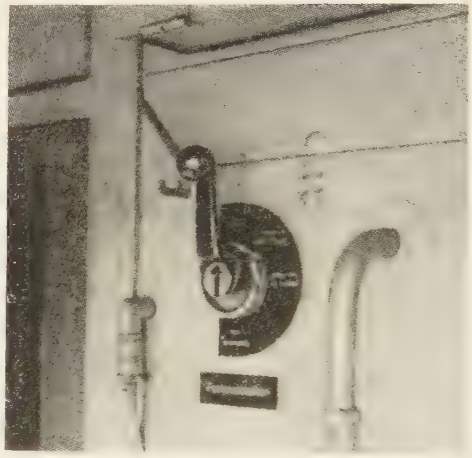


Fig. 7. — Wireless commutator switch.

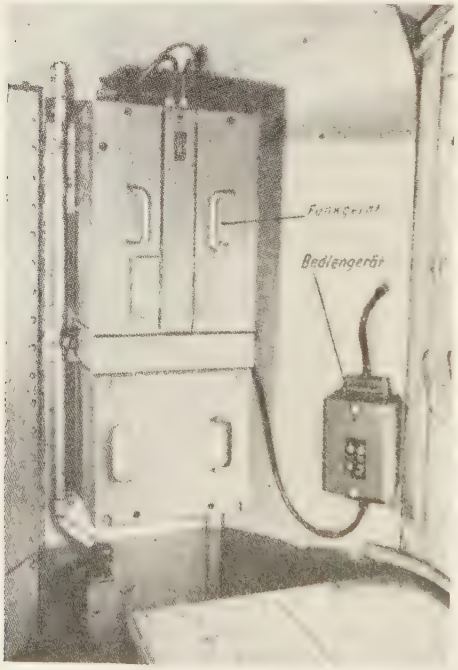


Fig. 6. — Wireless sets and control apparatus on the locomotive.

N. B. — Funkgerät = wireless set — Bediengerät = control apparatus.

Fig. 8. — Microphone/loudspeaker set and speech button.

the transmitter and receiver with the aid of a separate 12 V battery. The heating voltages for the sets are taken direct from the 12 V battery. In the current converter, the D.C. voltage of 12 V is chopped with the aid of a converter relay, raised by means of transformers and converted to direct voltage by means of flat rectifiers and filter elements.

Structurally, transmitter, receiver, aerial switch and direct converter form separate units which are mounted on the same frame and inter-connected by terminal strips and appropriate wiring. Figure 6 shows the wireless sets in No. 1 Cab of the electric locomotive. The *aerial* mounted on the vehicle is a Kathrein aerial normally used for the radio-telephony system in marshalling yards.

With the aid of a *special control apparatus* (fig. 6), the installation can be optionally set for two inter-com frequencies, whilst the sound volume of the microphone-loudspeaker set can be regulated in three stages. The control apparatus also carries two pilot lights « S » and « E ». When working for remote control operation, both lights are illuminated. When working with the radio-telephony system, either one or the other of these lights is

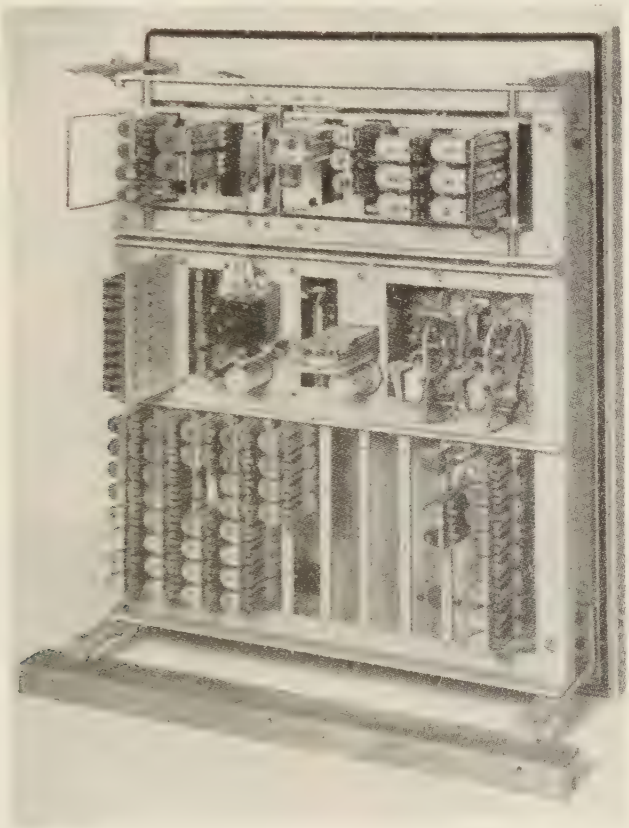


Fig. 9. — Remote control set on the locomotive.

illuminated, according to the position of the speech key. All other switching operations are carried out with the aid of the *wireless commutator switch.* This commutator switch (fig. 7) has the following positions : « Out », « Radio-telephony working without preheating of remote control apparatus », « Radio-telephony working with preheating of remote control

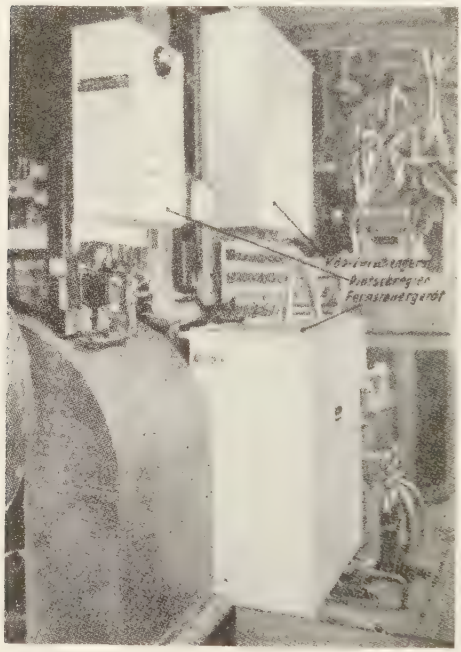


Fig. 10. — Remote control set, intermediary control apparatus and Pintsch regulator on the locomotive.

apparatus », « Remote-control operation ». In the « Out » position, the entire apparatus, including the radio-telephony system, is out of action. The position « Radio-telephony working with preheating of remote control apparatus » is used if the radio-telephony system is used exclusively and the use of the remote control system is not envisaged within a foreseeable time. In the position « Radio-telephony working with preheating of remote control apparatus », the remote control apparatus such as, e.g., the single-channel wireless telegraphy set are heated while the operation of the radio-telephony system still continues. In the « Remote control operation » position, all the installations required for remote control receive the full working voltage. Moreover, the radio commutator switch serves to operate the switch of the compressed air installation so that a rapid brake application can be obtained if the radio-transmission channel or the selector of the remote control set fails. This operation is accompanied by the cutting out of the traction motors.

To ensure telephone facilities, each driving cab is equipped with a microphone-cum-loudspeaker set with speech key (fig. 8).

b) *Wireless telegraphy set.*

In the same way as in the stationary installation, the pilot note of 2 940 cycles is generated on the locomotive for the radio communication between the locomotive and the control post and is chop-

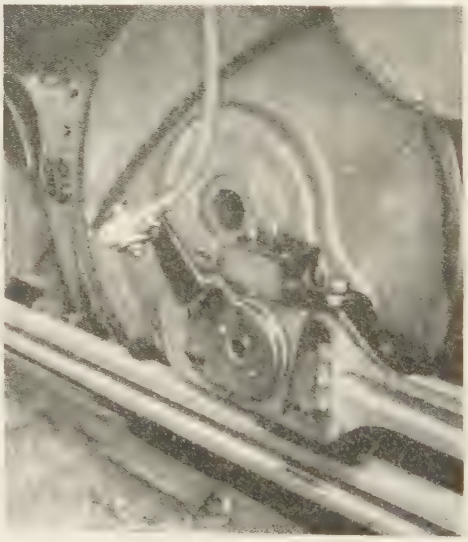


Fig. 11. — Deuta device (installation photograph).

ped by the impulse telegram during the transmission of an order or an acknowledgment. The receiver of the wireless telegraphy set works under the same conditions. The set is therefore identical with the one used for the stationary installations, the only difference being that it is designed for a direct current voltage of 24 V.

c) *Remote control set.*

The remote control set of the locomotive (fig. 9) serves, like the one of the stationary installation, to set up and receive the impulse telegrams. The long impulses and long intervals are again produced with the aid of a rotary selector which according to the message to be transmitted (e.g. « locomotive moving in the wrong direction ») causes the variation of the releasing time constant of the impulse generator relays for a given step of the selector through modifying the resistance. An impulse telegram from the locomotive to the control post includes all the stored messages. The transmission process is released whenever a new message of the modification of an earlier message is offered.

When an impulse telegram conveying an order has been received, the installation verifies, first of all, whether the telegram has been received without fault, and whether it contained the prescribed number of prolonged signals. Only then is the recorder order transmitted for interpretation i.e. for the control of the locomotive. At the same time, the transmitter of the remote control set is energized in order to acknowledge the receipt of the order. The transmission of the acknowledgment is accompanied by the repeated transmission of all the messages still outstanding.

The remote control set of the locomotive is connected to a buffer battery of 24 V. Voltage fluctuations of + 20 and — 10 % are still permissible. With these voltage fluctuations, the distortion of the impulses varies between + 3 and — 1.5 %. The two impulse receivers (i.e. those of the stationary and vehicle-mounted installation) can take impulse distortions of ± 15 % without difficulty.

Figure 10 shows the installation of the remote control set in the machinery compartment of the electric locomotive.

d) *Intermediary control gear.*

The intermediary control gear, likewise housed in the machinery compartment of the locomotive, is controlled by control relays of the remote control apparatus which are designed like telecommunication relays. The intermediary control gear serves to operate the appropriate contactors of the locomotive control.

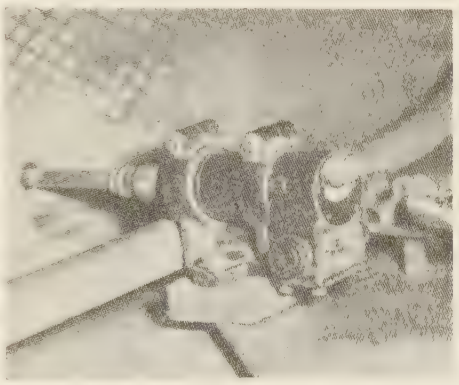


Fig. 12. — Drive of the Deuta device.

e) *Deuta apparatus.*

The Deuta installation (fig. 11) serves to indicate, during the start of the locomotive, the indications « locomotive running » or « locomotive moving in the wrong direction ». It is connected with one of the driven wheels by means of flexible shafting (fig. 12).

f) *Electric power supply.*

The electric power supply of the installations on the locomotive is ensured by a 24 V battery, buffered by a generator and connected by means of a Pintsch regulator (fig. 10) to a 12 V battery. The 24 V battery feeds the remote control sets and the wireless telegraphy set, whilst the 12 V battery feeds the wireless sets.

D. — Conclusion.

The first short-time tests of the remote control installation which were carried out with drivers who had no special training, were extremely satisfactory. It will not be possible to pronounce a final judgment on the installation before the staff have become fully familiar with the operation and the working has been adapted to remote control operation.

[621 .335 (43)

The mechanical part of the new single-phase, high-power, motor coach set, series E.T. 30 of the German Federal Railways,

by Eugen Lippl, Munich.

(Continuation and end) (*).

(*Elektrische Bahnen*, Nos. 9 and 10, September-October 1956.)

12. Body work.

Apart from the luggage compartments, coaches « *a* » and « *b* » are identical. The body of the middle coach should also correspond, in most respects, with those of the motored coaches and — apart from difrences inherent in the plan — be capable of adaptation to the simpler conditions of weight by reduction of plate and frame sizes only. The advantages in construction thus obtained are greater than those which would still be possible by a lighter construction of the centre coach. Moreover, this provides, in the *design of a heavy body*, the essential conditions for a standard form of construction.

The design of an electric motor coach body is one of the most difficult constructional problems. Firstly, there is the obvious requirement to provide the motors with the most suitable mounting for highest running quality and performance. In addition, their price must be reasonable even though the body, contrary to other coaches whether motored or not, also carries the whole of the electrical equipment.

In motor coaches built previously, the transformer was located directly above or below the floor and mounted on the pivot beam over the bogies to avoid large twisting moments in the body. This arrangement was not possible in the ET 30 as all available space in the bogies was taken up by the traction motors and corresponding ventilation ducting.

The transformer, like all the electrical and brake equipment, had therefore to be located between the bogies under the floor, which was 1 150 mm above rail level. However, the heaviest parts of the electrical equipment could not be positioned to take account of the strongest parts of the body frame, but so that the loads on the driving axles remained within narrow limits, to restrict the adhesive weight at the rear and also to restrict the permissible vertical axle load.

The arrangement of loads in the motor coach and the consequent diagram of bending moments make necessary a tubular form of construction which is in fact advantageous in providing the maximum rigidity within the limits of the gauge. This form of construction has already been used, under the name of « framed monocoque construction » in the motored VT 08, VT 12 and ET 56 (4). Because of the greater stress in the body by the electrical equipment, increased number of entrances and wider windows, the need to make maximum use of the properties of materials to reduce

(4) See Taschinger : « Eisenbahn Technische Rundschau », 1954, No. 6.

(*) See « Congress Bulletin » for July 1957, p. 551.

weight and dynamic tractive and acceleration efforts, it was essential to make further improvements in tubular construction for the ET 30, to provide simplicity and cheapness.

It was also necessary to overcome design difficulties in connection with the size and weight of the motor equipment and it was not, in every case, possible to reconcile the most desirable layout with the body arrangement. Because of the concentration of motive power in the two driving bogies, the passage could be taken as far as the vestibule nearest to the driving cab (fig. 16) so that the change of level is not very noticeable and only affects the luggage compartment and the next section of the passenger compartment. Throughout the remainder of the set the floor level is 1 150 mm above rail.

There are however some repercussions on the bending stresses in the metal framework, the bend coinciding with the door opening and located at a point where

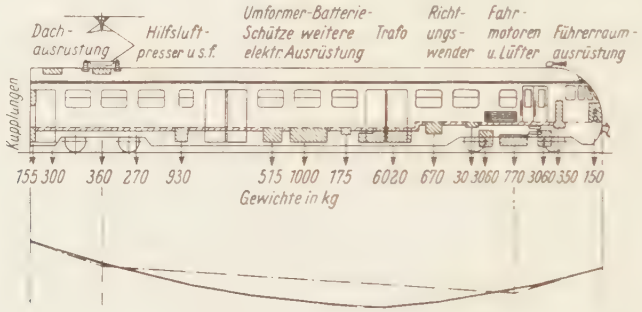


Fig. 16. — Weight of electrical equipment and bending moments.

—.—.—. calculated moment curve.
——— measured deflection.

N. B. — Kupplungen = couplings. — Dachausrüstung = roof equipment. — Hilfsluftpresser u.s.f. = auxiliary compressor, etc. — Umformer — Batterie... = converter, battery, breakers, other electrical equipment. — Trafo = transformer. — Richtungswender = reverser. — Fahrmotoren u. Lüfter = traction motors and blowers. — Führerraumausrüstung = cab equipment. — Gewichte in kg = weight in kg.

giving a one-hour power of 440 kW per driving axle at 70 % V_{max}, the diameter of the driving wheels had to be 1 100 mm with a tyre wear of 40 mm to conform to German operating instructions (30 mm under the Swiss gauge) and the height of the floor above the driving bogie of 1 330 mm. The diameter of the carrying wheels rises to 950 mm and the height of the floor above the carrying bogie to 1 150 mm.

The change in height of the floor above the driving bogies has had to be accepted. Its location was governed in part by the wheelbase of the driving bogie (3 600 mm) it is impossible to make use of the skirting to increase the moment of resistance. The heaviest item of electrical equipment, the transformer group (about 6 t) has to be carried as a separate load (fig. 16).

A simple solution, related to the type of door used, using a portal frame (fig. 17 and 18), rigid construction in box shape of the footboards and arched stiffeners in the form of hollow beams has given this most important section of the body the necessary strength, which has been confirmed by load testing. It was possible to accommodate the transformer satisfactorily. In both directions of travel, a sufficient intake of air

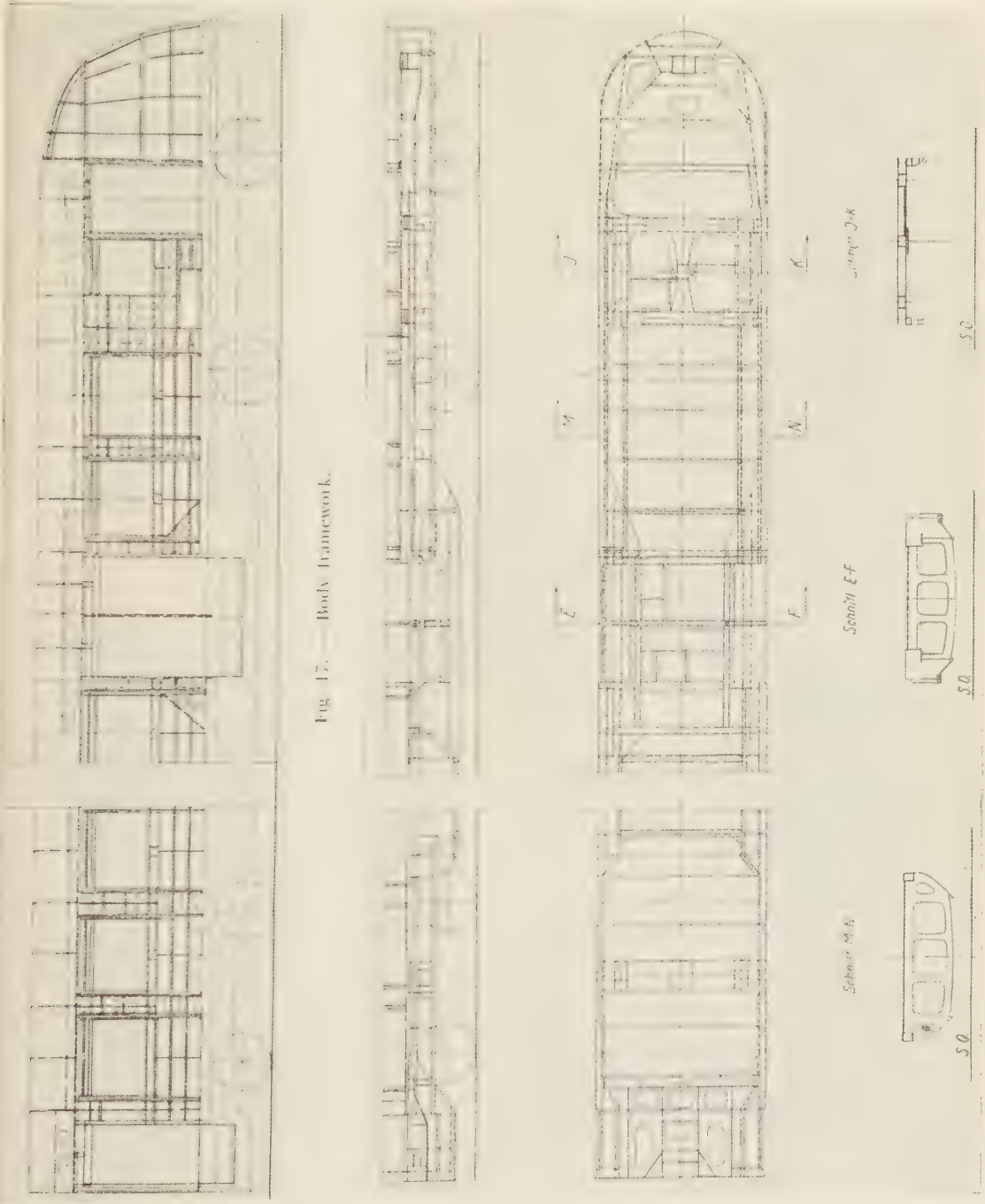


Fig. 17. — Body framework.

Fig. 18. — Body underframe.
N. B. — Schnitt = section.

has been obtained and this has been further reinforced by cooling air pipes supplied from the sides inlets in the frame and an exhaust pipe directed upwards and inset in one wall of the vestibule.

The *rounded shapes of the front end,* with segmental cab windows sharply inclined towards the rear, a characteristic of the new railcars of the Federal Railways, has been retained (fig. 19). The cab has been fitted with rather higher windows to improve the field of vision. At the same time, the appearance of the front end of the coach remains very satisfactory and also provides an outward indication of the exceptional power of the motor coach set.

The *front end* of the frame, with a centre buffer/coupler of the Scharfenberg type, is a heavy type buffer, extremely powerful, which transmits drawgear forces directly to the main longitudinals at the same time leaving a space above the first axle with no longitudinal beam to hinder access to the traction motors (fig. 20).

For connection to the bolster pivot, a height of 100 mm only was available. It has thus been quite impossible to use a normal pivot with the low bogie drive essential in this case to limit unloading the axle as a result of tractive effort, which goes up to 9 tons per bogie, without heavy plate construction, perfectly stable but allowing for the considerable amount of registration movement needed.

Use has therefore been made of the bending moments of the pivot to reduce the effects on plate members of the body frame, as well as horizontal tractive and brake forces, to a degree where small beams and light-gauge plates can easily absorb the stresses. The pivot is a solid « T », which can move around a longitudinal axis on two silentblocs mounted in the two stays. The horizontal forces from the pivot are transmitted horizontally to the two box stays in the form of vertical and horizontal components and cause bending stresses which are easily absorbed. The silentbloc mounting of the oscillating axis is designed also as a stop block and serves to transmit tractive and brake efforts to the body frame. Transverse efforts from the bogie are absorbed by rubber mounted rods, set between the upper parts of the swing bolster and the frame middlebearer.

Fig. 19. — Front end arrangement.

For the carrying bogies of the motor coaches and the centre coach, use has been made of the normal fixed pivots on wide pivot beams carrying the side rubbing blocks (fig. 21). The *part carriyng the end vestibule* (fig. 22) is combined with the rigid drawgear headstock carrying the

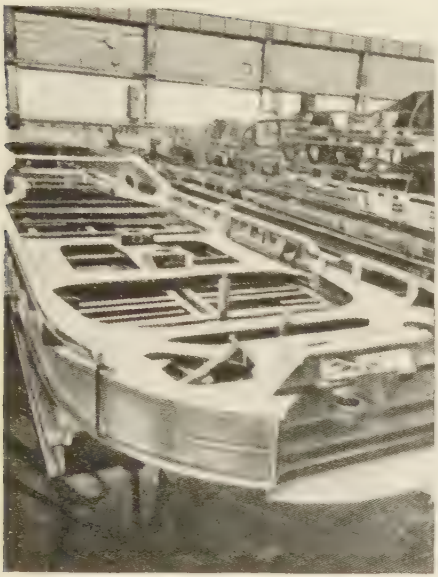


Fig. 20. — Leading part of underframe.

blocks, buffing plate and screw drawgear by an arrangement of fabricated plate and enclosed by a vertical plate with a very low bottom edge.

The considerable loads have necessitated the greatest care in the design of the metal structures in all sections. Where the electrical equipment allowed it to be done, the coach casing has been used to provide as high a moment of resistance as possible. In the other sections, for example above the bogies and under the transformer, are strengthening beams integrated into the load-bearing structure. The side walls, roof, corrugated floor, corrugated top flooring and side walls are incorporated in the load bearing structure. Between the door portals are placed, under the facing, two main longitudinals, U shaped 140 × 5 × 4, turned inwards and spaced by distance pieces. The edges of the skirting are reinforced by a 3.5 mm triangular metal beading. The roof frame at the junction with the sides is U shaped, with unequal arms, 95 × 55 × 25 × 3, the upper face having a chamfer is 2 mm thick with re-

Fig. 21. — Centre coach, rigid coupling, underside.

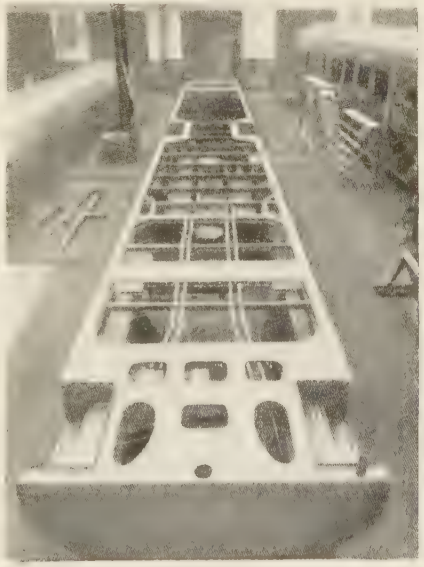


Fig. 22. — Centre coach, rigid coupling, top view.

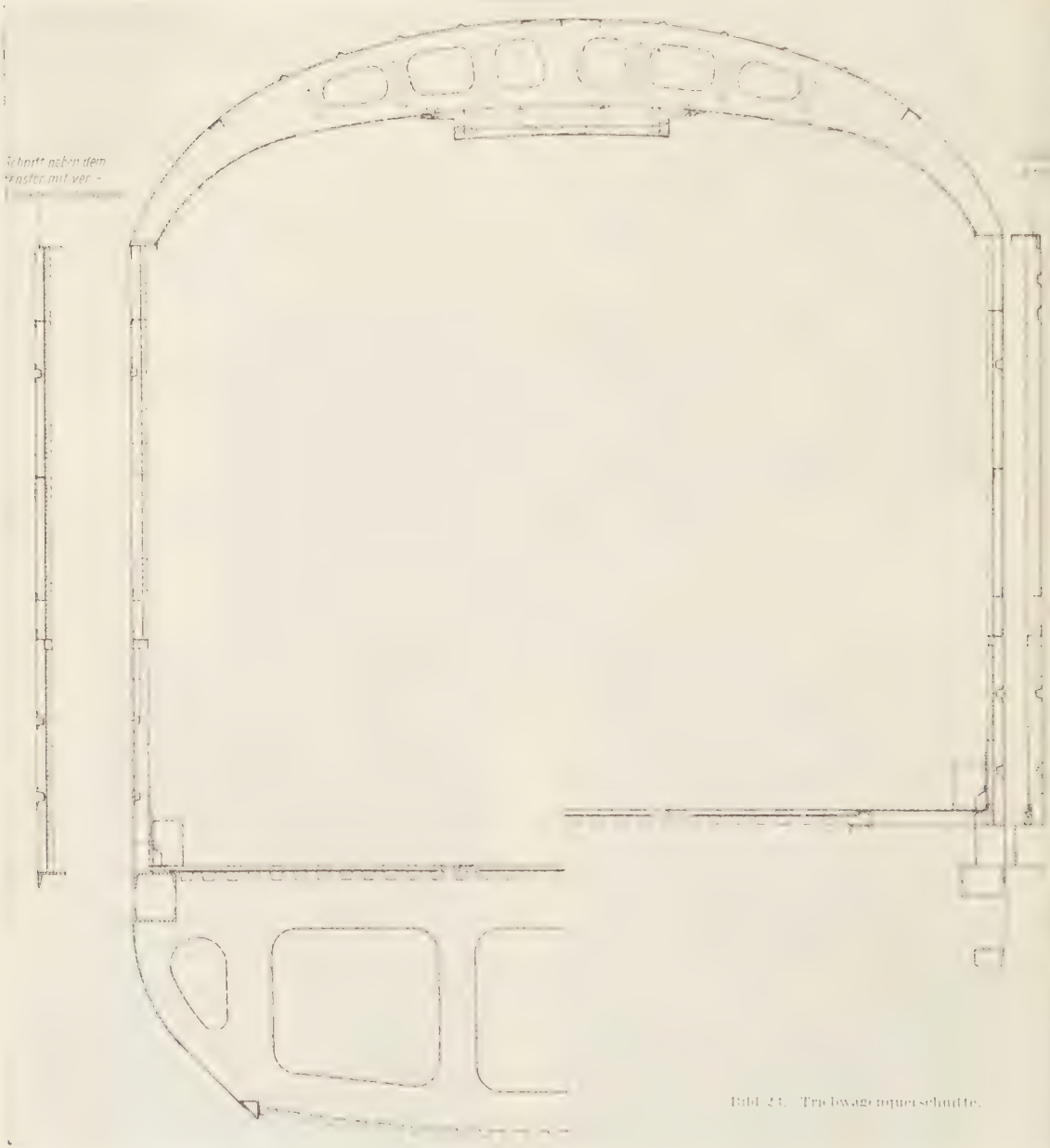


Fig. 23. — Motor coach.

N. B. — Fensterschnitt = section through window. — Schnitt neben dem Fenster... = section near window, with reinforced side wall.

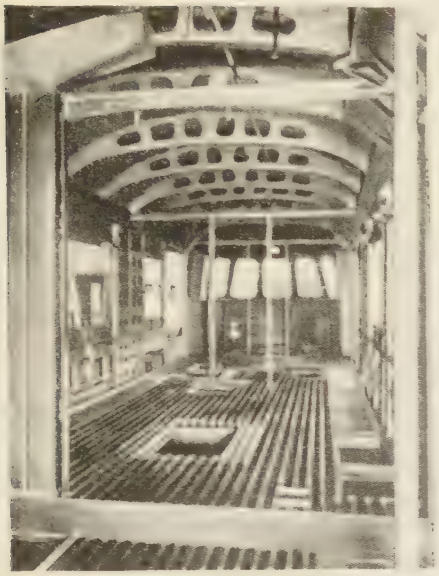


Fig. 24. Interior view of body structure.

inforcing rib. The lower corrugated skirting plate is 1.5 mm thick in the motor coach and 1.25 mm thick in the centre coach; the flooring is 1 mm gauge in the leading section of the motor coaches and 0.75 mm, elsewhere, the side plating is 1.5 mm, the arch of the roof 3 mm and the centre of the roof 1.75 mm in the motor coach and 1.5 mm in the centre coach. The latter plate is stiffened by eight corrugations. The waist rail is Z shaped, 51 × 33 × 3, the upper window beams L shaped, 30 × 30 × 3.

From the front to the first vestibule and above the carrying bogie of the motor coach, the window standards are reinforced internally by 2 mm perforated plate. Above the vestibules and in the front part of the motor coach, the arch sections of the roof are doubled (fig. 24).

The parts in tension and compression are strengthened by floor and roof arches 2 mm in the motor coach and 2 mm and 1.5 mm in the middle coach (fig. 25) and by transverse corrugated partition walls at the end vestibules.

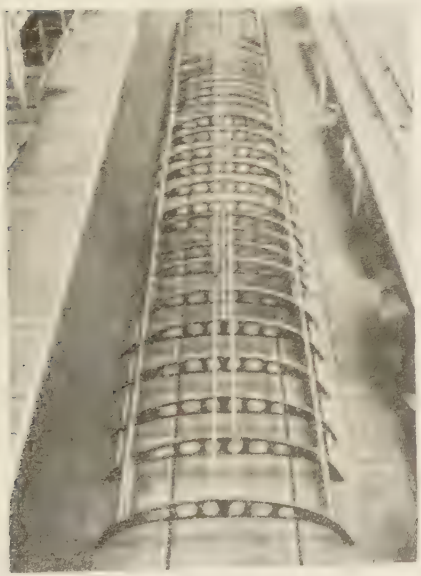


Fig. 25. Roof skeleton

Fig. 26. — Body structure. — Centre coach.

In the spaces enclosed by the arches are the electrical and brake equipments, protected from dust and accessible by side doors. The ends of the corrugated floor cover have manholes. They give access to the body frame (fig. 21). To avoid penetration of dust, the enclosed space is pressurised by a fan in the roof.

The bodywork (fig. 26) has been subject to a test load twice the working load (passengers, equipment, luggage and 30 % shock load) with results practically identical with the theoretical calculations. The stresses reached 60 % of the maximum permissible stress for ST 37 steel. In spite of the heavy motor load the deflection of the body (8 mm) is less than in comparable coaches of the same length. The line of elasticity (fig. 16) coincides with the load curve, stresses are uniformly distributed even at critical points. Accumulation of stresses has been avoided. At the same time, the short space for deflection between the centres of the driving bogie and the transformer demands high resistance to bulging of cover plates even though they are only lightly stressed.

Even in the preliminary construction stage, care has been taken to provide the best possible degree of *noise insulation*. The false-floor cover provides an excellent sound insulation. Above the bogies and covered by a double fabric, are twin glass fibre mattresses weighing 3 kg per square metre. The ends are insulated by pads of glass wool, sewn in crepe paper and muslin, 100 × 60 mm, weighing 110 kg/m². The roof and cab partitions have sprayed cork, 6 mm thick. There is no metal link between the bogies and the body. All connections are insulated by rubber. In the portion of the body between the driving bogies, the noise does not at any point exceed 80 phones. From provisional measurements, it rises to an average of about 75 phones at 120 km/h on 30 m rails.

Fig. 27. — Arrangem

N. B. — Bremszylinder = brake cylinder. — Festpunkt = fixed point. — Sandkasten = sand box. — Motor = m
= transformer. — Schaltwerk = switchgear. — Fehlerstromwandler = emergency current converter. — Brem
Heizschütze = heater switches. — Lüfterschütz = ventilator switches. — Luftpresserschütz = compressor switc
Mess- und Motorstromwandler = motor and instrument current transformer. — Indusi-Umformer = Indusi conve
motor. — Wagenhauptheizschalter = main switch for carriage heating. — Hilfsluftpresser = auxiliary compres
Notbremsventil = alarm signal valve. — Vorsteuerbehälter = control reservoir. — Hilfsluftbehälter = auxili
übersetzer = pressure regulator. — Drosseldüse = baffle pipe. — Vorratsluftbehälter = compressed air cylin
becher = drain cock. — Rückschlagventil = non-return valve. — Öl- und Wasserabscheider für Hauptschalter

13. Brake.

Double shoe brakes were used on the first series. One set is fitted with disc brakes, designed for the first time for operation by motor in the bogie included in

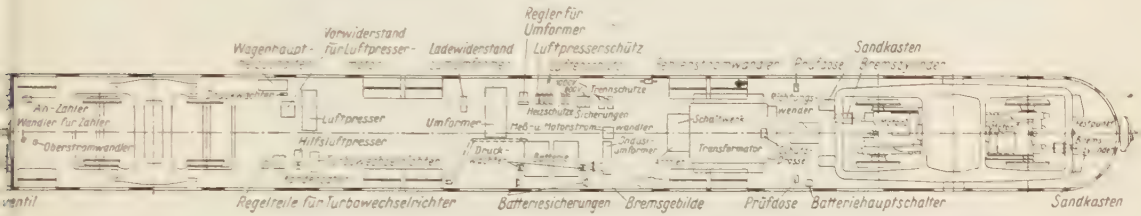
It was not easy to find a place for *electrical and brake equipment*, as it was necessary to have easy access. A glance at the arrangement of equipment and connections will give an idea of the difficulties which have had to be overcome (fig. 27). Some of the items, for example the battery and the air compressor are frame mounted and can be removed and replaced on rollers to facilitate servicing.

the set. The Knorr, non-adjustable, compressed air brake, with quick-acting valve, has an additional electric control allowing a closely graduated progressive application and release with a brief application period and low consumption of air.

To limit tyre wear on driving wheels whilst retaining the greatest possible power in the brake, the carrying bogies have been fitted with a quick-acting two-stage brake, 100 % and 75 % and the driving

14. Driving bogie.

In the *driving bogie* (fig. 30) the stresses approach those of a locomotive bogie because the two traction motors, owing to their overload capacity, reach starting powers of 880 kW each. The two nose-suspended motors and separate blowers weigh, with the blower groups, 7.26 t. Nevertheless, efforts have had to be made to provide the same running qualities as



ient in the frame.

auptschalter = main battery switch. — Richtungswender = reverser. — Schutzdrossel = fuse. — Transformator e equipment. — Antrieb = drive. — Batteriesicherungen = battery fuses. — Trennschütze = section switches. — ür Umformer = converter regulator. — Ladewiderstand zum Umformer = resistance for loading the converter. — ichter = pressure regulator. — Vorwiderstand für Luftpressermotor = resistance control regulator for compressor chselrichter = rotary converter. — Ah-Zähler = ammeter. — Wandler für Zähler = ammeter transformer. — . — Löseventil = drain valve. — Auslösezug = lock release. — Schleuderfilter = centrifugal filter. — Druck- itsluftbehälter = emergency reservoir. — Luftfilter = air filter. — Druckminderventil = reducing valve. — Tropf- er separator for main breaker.

bogies with a normal speed brake of 80 %. The two brakes are linked through a feed cylinder, driving bogie relay valve and pressure regulator on the carrying bogie.

Use has been made for the first time of a new type rapid compressor, the VV 130/200, with a V arrangement of two pairs of high and low pressure cylinders. For a final pressure of 10 atm the amount of air provided is 600 l/min at 1 650 r.p.m. with a consumption of 5.7 kW (fig. 28).

In one carrying bogie of the centre coaches has been fitted a new manual brake control (fig. 29) located directly between the brake cylinder and the compressed air brake rigging. On the bogies which each have a single brake cylinder the fitting of the hand brake is considerably simplified.

With regard to the *running gear,* completely new methods have been adopted. with a good bogie for an ordinary passenger carrying vehicle. Moreover, it must be capable, without mechanical modification, of speeds up to 160 km/h and over, despite an axle load of 20 t. The German Federal Railways have never before used a nose-suspended motor with a power approaching 440 kW and such weight for a speed of 120 km/h. It was therefore necessary to examine very carefully the design of all parts affecting the running of the vehicle.

The dimensions of the driving wheels were determined by the size of the motor, the permissible tyre wear, tractive efforts, and maximum loads. The 1 100 mm diameter of the driving wheels gives a distance relative to the floor sufficient to accommodate the motor gear case. With a tyre thickness of 75 mm, wear in German internal traffic can go to 40 mm. Because of spor-

adic hardening experienced with shoe-type brakes and high tyre stresses, a metal of medium tensile, in accordance with U. I. C. leaflet 515, and heat-treated, has been used uniformly for driving and carrying wheels. The connection of the single-dished wheel to give the most suitable form without any notching effect. When new a train of wheels weighs 1 485 kg and has an electrical resistance of less than 0.01 ohms.

The *driving axlebox* (fig. 31) and its guides are of a completely new principle.

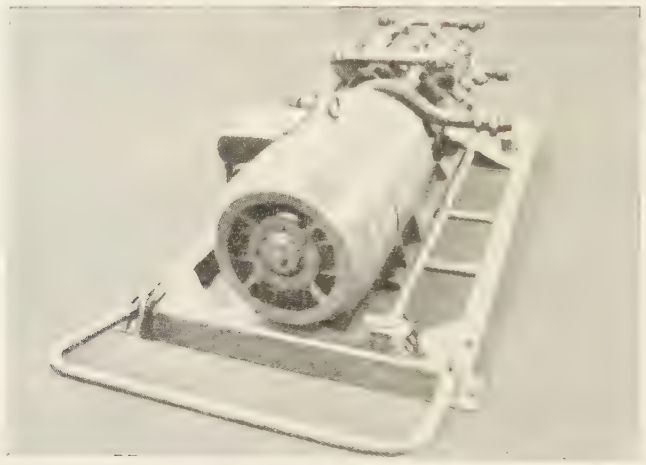


Fig. 28. — Compressor.

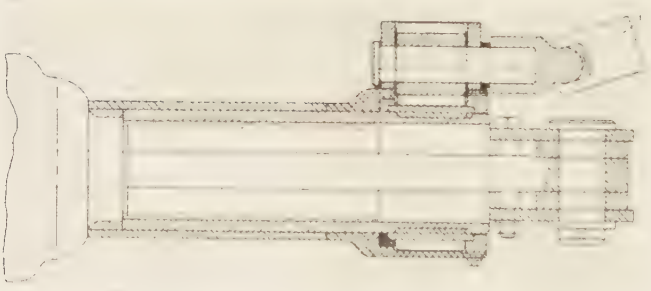


Fig. 29. — Manual brake control in carrying bogie of centre coach.

centre to the hub has been carefully designed, large 56 and 75 mm spokes have been used. Keyways have been provided to allow the use of oil pressing-off. Because of the nose-suspension, the driving axle has ten variations of diameter with ground surfaces, the changes requiring special study

With a 20 tons axle load and the heavy active masses of the nose-suspended motor, a simple and robust solution can only be obtained by profiting from past experience — not always satisfactory — with driving axleboxes, to reconcile as far as possible the technical requirements for bearings,

guides and suspension with the influences of the method of drive and motor suspension. It was necessary to obtain exact verification of the resonance conditions of the whole system, made up of the following components :

motor, gears, axle shaft, roller bearings, guides, transverse guide, longitudinal guide, flexible suspension,

to arrive at a solution which in present technique gives a practical realisation of the desired qualities.

Careful investigation led to the use of a double row of cylindrical roller bearings (fig. 31) of 130 mm bore and 260 mm outer race diameter with an inner spacing ring 30 mm thick and an outer spacing ring of 27 mm, with a fixed shoulder for the inner row and separate retaining ring for the outer row. The inner rings are secured by a grub screw, the outer ring by a cover plate fixed by eight bolts from the axlebox guide to the box body through sleeves.

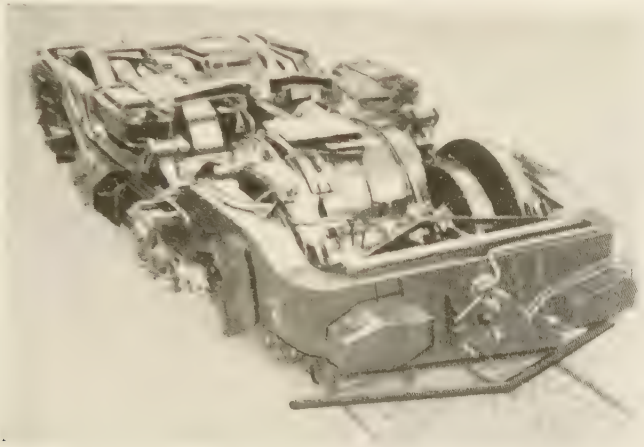


Fig. 30. — Driving bogie.

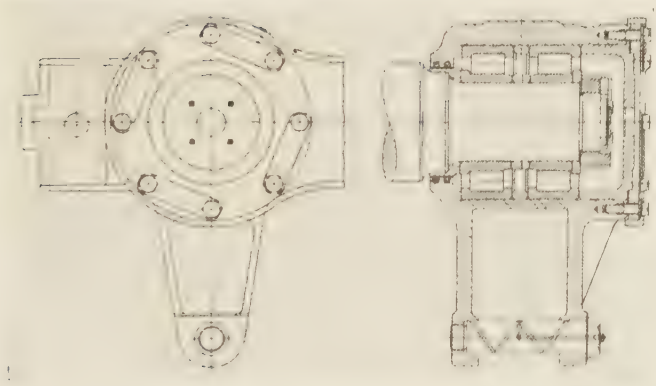


Fig. 31. Driving axlebox.

The body of the box is very rigid, cylindrical in shape. Two trapezoidal lugs (fig. 31 and *d*, fig. 32) take the centre (*e*, fig. 32) of the lower laminated spring *a*, the buckle (*b*) of which is carried by the roller seating. A second lug in the centre line of the bearing takes the flexible transverse guide which forms, in conjunction with the normal axle guide (*n*) a *completely wear-free axlebox guide*. It is this

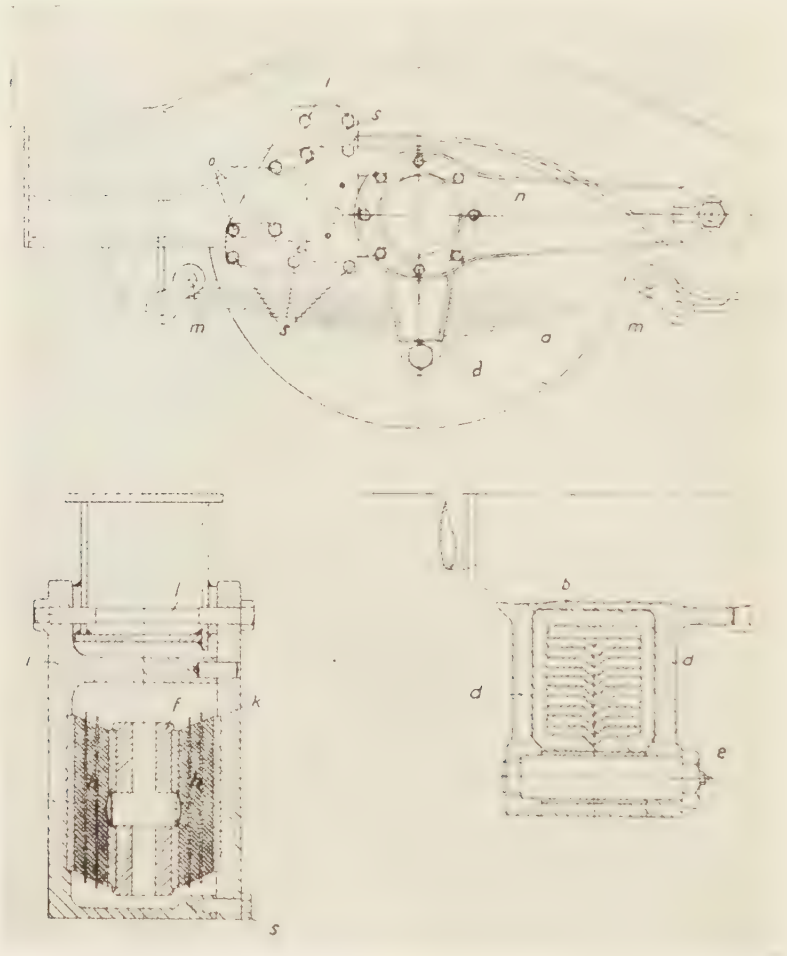


Fig. 32. — Driving axlebox guide.

centre bearing. The leaf spring is carried on the frame by the normal twin links (*m*). The body of the box is thus free from additional stress caused by twisting or bending which might cause warping of the which gives the ET 30 driving bogie its characteristic appearance (fig. 32) and is necessary to allow a simple box design of frame without gaps for springs or axle-guides, with perfectly parallel axles, flexible

transmission of longitudinal and transverse efforts and easy dismantling, with or without motor, of the driving axles.

Longitudinal control of each axle is provided by two guides (*n*) which are mounted on a centre fixed to the solebar and ensure, by means of silentblocs and excentric sleeves, with 3 mm play, the parallelism of the axles.

For flexible *transverse guiding* without play, the lug (*f*) of the axlebox body is put in pre-tension between triple layers of rubber (*h*) in a guide-box (*i*, *k*) and the whole is fitted to the frame, with the axle and spring mounted, by means of adjusting bolts (*l*, *s*, *o*). The layered rubber allows play of the axle spring to ± 17.5 mm with an initial transverse tension of 1 950 kg acting

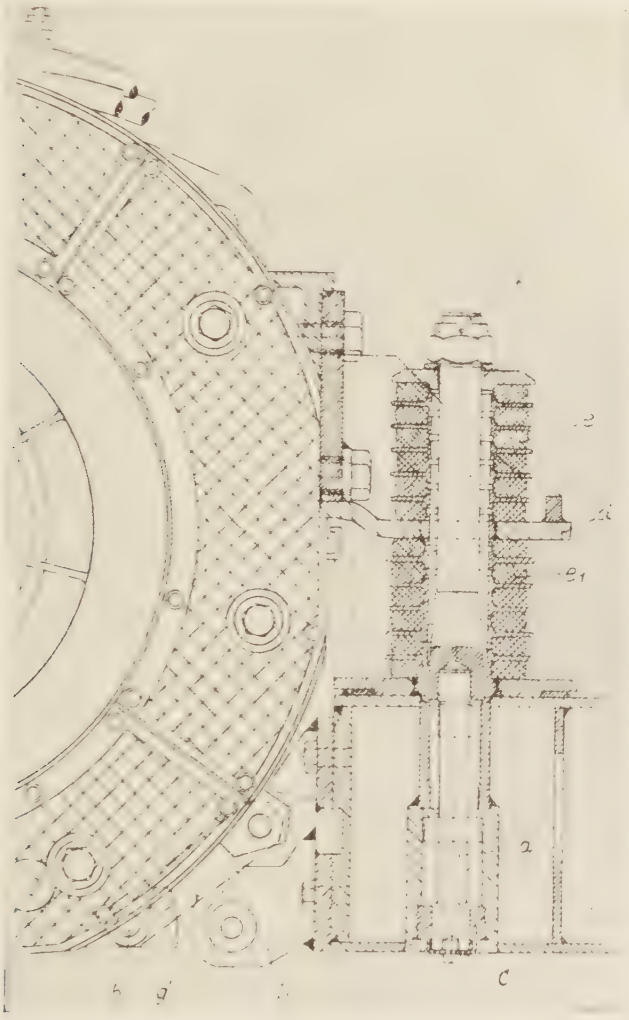


Fig. 33. — Motor suspension.

as an auxiliary spring of 30 % but with good damping effect. Transversely, the amount of play is limited to ± 2 mm. Within these limits, the rubber layers have

was attempted is of great importance to the life of a nose-suspended motor; it has been completely successful within the mileage so far covered. Repeated pulsator tests

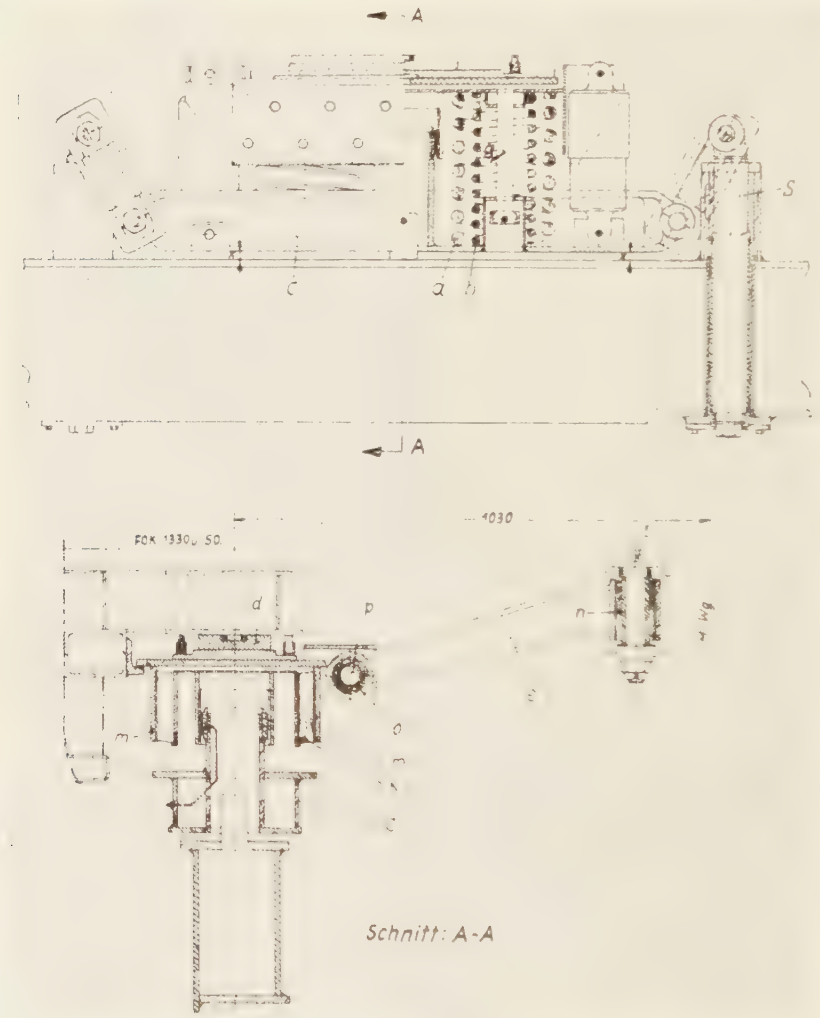


Fig. 34. — Body suspension.

a recoil effect which increases progressively up to 6 t per axle from the central position. The absorption of transverse efforts and the reduction of peak shocks which

under greatly increased stresses have shown the durability of the rubber layers. They are cheap and easy to replace. The lug for transverse control also limits the play

of the spring and transverse play in the guide box.

Motor suspension is intimately connected with the guiding and flexible suspension of the axlebox. According to the masses concerned and the method of absorbing efforts, the suspension and rotary movements can set up a resonance which, especially at high speeds, allows a pulsatory torque (33 1/3 Hz) to have an undesirable effect on the running. It was thus necessary to consider the dynamic behaviour which was likely to occur and design the whole assembly to avoid resonance. Moreover, it was necessary to install the equipment in a very restricted space and to decide the way in which it could be mounted on the middle bolster. It had to allow removal of the motor upwards or downwards without lifting the body. Figure 33 shows the motor suspension. This bears, through a bracket (*d*) on a rubber spring formed of six washers (e_1), 138 mm diameter and 25 mm thick, separated by metal plates. A similar spring (*e*), 126 mm diameter is set on the bracket. Both are compressed by a through bolt (*f*) between two plates so that neither of the two sets of rubbers entirely loses its initial tension when the motor moves. The through bolt (*f*) and the bottom compression plate are located against the stay by a fixing screw (*a*) under it. When the motor is taken out, this screw releases the suspension and enables it to be taken up. In the case of removal downwards, the motor is linked to an emergency suspension (*b*) by a foot (*g*) and bolt (*h*) and when the axle is dropped is pivoted to pass downwards along the bolster by continuing to lower the axle after securing the motor. Refitting the motor is done by carrying out the same operations in the reverse order.

Figure 34 shows the body suspension. It

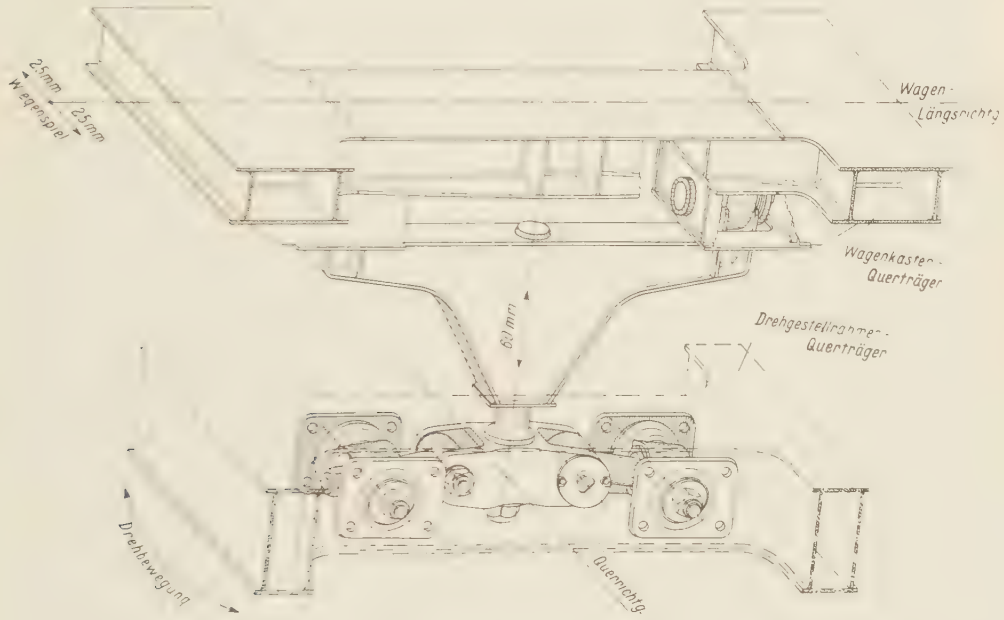


Fig. 35. — Low pivot.

N. B. — Wagen-Längsrichtung = along the coach. — Wiegenspiel = play of swing bolster. — Wagenkasten-Querträger = body cross-bearer. — Drehgestellrahmen-Querträger = bogie frame stay. — Drehbewegung = rotary movement. — Querrichtung = across the coach.

is carried on rubbing blocks (*d*) of the *two swing bolster spring caps.* These are linked to clamper rings and centres (*s*) which are adjustable and mounted on the longitudinals. Each cap holds two nests of helical springs (*a, b*), pierced by a fixing bolt (*g*). In the middle of the cap, the upper part (*m*) is held by a bronze convex washer in a « ferrozell » sleeve. This washer is pressed on to a welded tube at the bottom of the cap (*c*) and has a hole to take a bolt fixed to the bogie frame to restrict the movement of the swing bolster. The upper part carries two layers of rubber (*k*) to ensure a resilient link with the support for the top rubbing block of the swing bolster. This is guided transversely by a lever (*e*), mounted on silentblocs (*o, p, n*) to avoid stiffness in curves. The guides are adjustable by executive centres (*l*) with 3 mm movement to allow for possible inaccuracy in construction.

The *low pivot device,* with « T » shaped, transverse oscillation, has already been mentioned (fig. 35), it rises to about 1 000 mm below the coach floor to a socket in the bogie frame. For this purpose, advantage has been taken as far as possible of the R. I. C. gauge to reduce to a minimum the off-loading of axles. The pivot is not inside the socket, but rotates in a ferrozell sleeve. When the springs of the bolster move, it engages the pivot of the driving bogie guide. To damp vertical spring movement and torsion movement due to striking the swing bolster, it is jointed on the bogie frame middle bearer through a series of silentblocs, one arranged longitudinally and three transversely. This arrangement is free from wear and requires no maintenance, it absorbs without shock the tractive and brake forces, damps the hunting and rotary forces to which they give rise and ensures efficient and progressive suspension, especially vertically.

Carrying the motors and the two groups of blowers, the brake equipment with two 10″ cylinders and a double shoe brake acting on both sides of the wheel and the necessary fittings — Indusi electro-magnet, flange lubricator, tachymeter and anti-slip device, four outer and two inner sanders, the sand pipes being adjustable in height, the driving bogie is a very complicated one and is unique in railcar design. However, it has been necessary to mount these components with the various requirements, often considerable, in regard to weight on a frame which is as simple as can be desired, is free from stress concentration and is robust.

It has been possible to provide a flat, low frame, without sharp angles, the main centre of gravity being very little higher than the axles, made up of all-welded box beams. The rectangular caisson frame has, in plan, two straight solebars which take the forces from the axles, body and springs, in the same plane without additional bending stresses. There is no break in the continuity of the caisson, which is particularly notable above the wheels. The axlebox guides eliminate the need for horn stays, with their construction and maintenance problems. The central part comprises two cross-bearers and a middle-bearer which are lowered to take the motor suspension and pivot as well as to act as a base for the two motor fan groups. These groups can be removed upwards or downwards. The bolster spring caps are set a small distance above the level of the bogie solebar. Finally, a design of frame has been arrived at which has only rectangular joints and basically flat surfaces; this design is very suitable for welding. The thickness of the St 37 plates used varies between 10 and 15 mm. To avoid any risk with the new type, the tension taken as a basis of calculations was limited to 800 kg/cm². Experience with the first series will show whether it will be possible to reduce the thickness of the plates.

15. Carrying bogie.

The *carrying bogie* used is of the *Munich-Kassel* type, designed for the ET 30 by the Central Office of the German Federal Railways, Munich, in collaboration with the Waggonfabrik Wegmann Co. of Kassel. It is a bogie with oscillating axles, including amongst other things a modified Wegmann toggle lever guide (fig. 36).

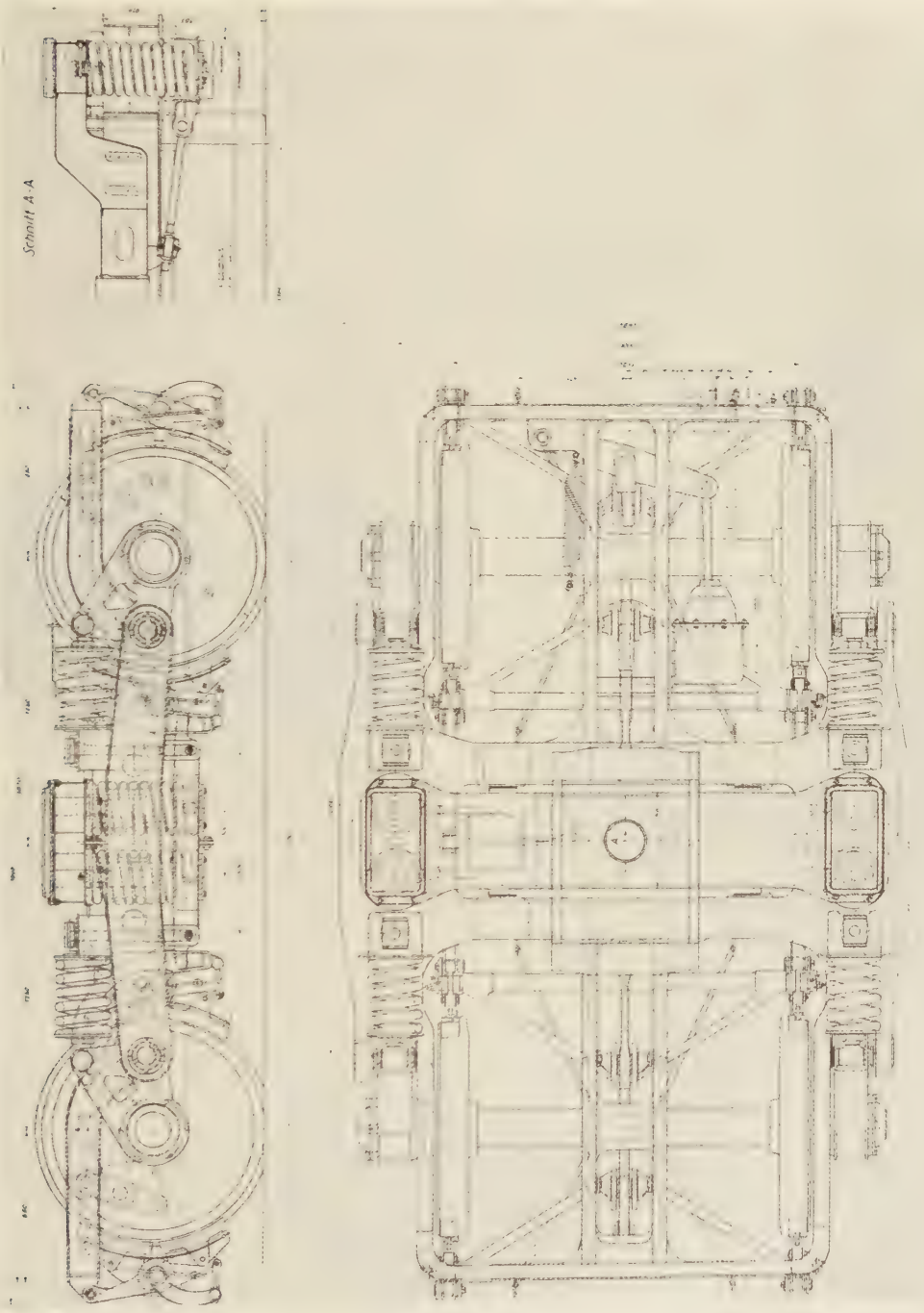


Fig. 36. — Munich-Kassel type carrying bogie. — General arrangement.

The following conditions were laid down for the new type :

freedom from wear:

plain frame reduced to axle level:

absorption of efforts from axles, springs, and body, without deflection:

limitation and reduction of bending moments by grouping the application points of forces;

wide bearing for the body:

mainly automatic damping, eliminating as far as possible the need for supplementary damping:

reduced frequency of vertical and horizontal oscillation:

greater rolling stability:

increased mileage between repairs:

suitability for shoe or disc brakes, or as carrying or driving bogie, without fundamental alteration:

suitability for use on motor vehicles or trailing vehicles.

The design of a new type had become necessary because on electric motor coaches, the space available in height, width and length is very little and the heavy mechanical equipment in the body makes great rolling stability imperative. The new type had to be capable of use, without modification of the main parts, despite widely different axle loads on the carrying bogie of motor coaches (up to 20 t for example on battery cars) from those on trailing vehicles with or without a driving cab, where they are, for example, 11 t on the middle vehicle of the ET 30 and 9.5 t on the driving trailer of the series 150 battery sets.

To this is added, particularly for electric motor coaches, the desire to improve stability in running and the cost per mile by the use of a type of construction which will reduce tyre wear. It was also necessary to have a lighter bogie, although the carrying bogies of motor coaches running with overhead contact wire have not the same urgent need for weight reduction. Furthermore, to allow standard manufacture the carrying bogies for the motor coaches and the centre coaches have been made identical, in spite of the great difference in axle load. The lighter, central coach has thus been given the same carrying bogie.

The carrying bogie has outside roller bearings (fig. 37). The axles run in triangular cast steel boxes, acting as toggle guides for double roller bearings of normal type 120 × 240. The axle guide is mounted in a large silentbloc resiliently, between the two cheeks of the bogie frame but without transverse play and located transversely, longitudinally and vertically (fig. 38).

The upper part of the angled guide bears against the horizontal axle suspen-

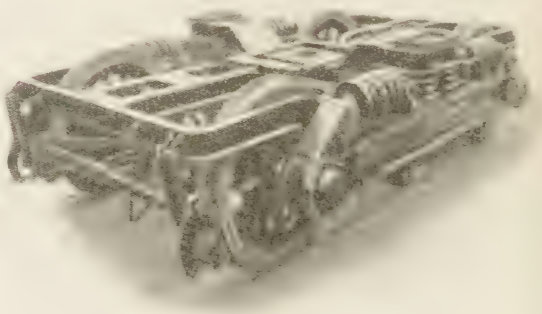


Fig. 37. — Munich-Kassel carrying bogie.

sion, which according to the load on it, comprises a single or double helical spring on a frame bracket. This also takes the suspension bolt of the cap carrying the bolster springs, the cap being held by vertical rings. The single or double helical springs rest on the cap and emerge through apertures in the solebar. The springs support the swing bolster proper, which is lowered in the centre and carries, at the ends, rubbing blocks with the same spacing as the axleboxes (2 000 mm) and at the centre the pivot socket which is a wear-free rubber moulding keyed to the steel. The caps are held transversely by cardan-mounted guides.

With shoe-type brakes the carrier frame for the rigging is taken from the ends of

the main frame near the toggle arm supports towards the bogie end.

The main frame is a caisson type, « H » shape, welded, with high diagonal strength. There has been no necessity to regulate the position of the axles because the stability of the frame and the ease of workshop machining guarantees precision.

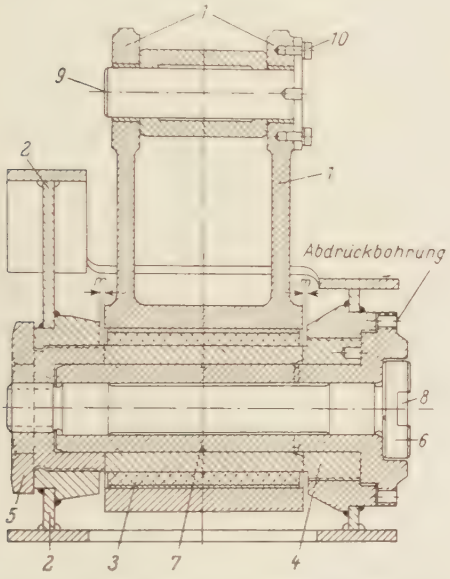


Fig. 38. — Axle guide on Munich-Kassel bogie.

1. Axle guide.
2. Bogie frame.
3. Silentbloc.
4. Outer tapped ring.
5. Inner tapped ring.
6. Fixing bolt.
7. Hollow centre.
8. Locking bar.
9. Cardan centre.
10. Fixing screw.

N. B. — Abdruckbohrung = extraction hole.

When the bogie is used as a driving bogie, the stays are used for suspension of the motor. The free space left by the longitudinals and stays between the axle and the stays allows easy installation of the motor equipment.

The Munich-Kassel type bogie was produced towards the end of 1953. Since January, 1954, four of these bogies have been running under an express motor coach with a maximum speed of 120 km/h. Measurements taken after mileages of 20 000, 100 000, 200 000, 300 000 and 360 000 km have shown that both horizontally and vertically the degree of stability has been greatly improved and frequency of oscillation reduced. There has been no noticeable reduction in running quality with the increasing mileage. From the point of view of steadiness in running and lack of reaction to track variations, the Munich-Kassel bogie is outstanding.

The four trial bogies have run 372 000 km without incurring any maintenance which could be attributed to the type of construction and without need for tyre-turning. At the end of 300 000 km an average wear on tread of 3.5 mm was measured and on the roots of the flanges 0.5 mm. Naturally, if the flanges become blunt, as the tread wears, the thicker part of the flange is measured. The profile remains true, however. In any case, this experience confirms the practical soundness of the design from which it has been possible to reduce tyre wear by means of simple constructional arrangements giving lower hammer-blow on flanges and reduced flange pressures. The mileages quoted are exceptional for motor coaches. Up to the conclusion of the tests, the bogies and axles have shown satisfactory running qualities. On one of the bogies, the two hydraulic shock absorbers in the swing bolster were removed, as an experiment, without any ill effects. In the fixed motor coach sets, transverse damping is unnecessary below 120 km/h.

On these favourable results, the Federal Railways have fitted all new motor coaches, including battery cars, with carrying bogies, and where the motor equipment permitted, driving bogies also, of the standard Munich-Kassel type.

The ETA 150 and ETA 176 battery cars, and the corresponding driving trailers, now fitted with Munich-Kassel type bogies, have provided confirmation in service of the test results.

The whole of the running gear of the

TABLE 6. — **Coach construction characteristics.**

	1	2	3	4	5	6	7	8	9	10	11
	Express steam train	Express steam train	VT 06 Railcar	VT 08 Railcar	Artic-ulated set	Express Inter-city set	ET 30	ESA 150	ETA 150 + ESA 150	ESA 176	ETA 176 + ESA 176
No. of seats	416	168	96	113	135	388	222	104	203	96	168
Available passenger area (m^2)	493.9	269.1	148.0	159.1	196.1	352.5	190	60.7	111.5	65	128.5
Available area per seat (m^2)	1.19	1.60	1.54	1.41	1.45	0.91	0.86	0.58	0.57	0.68	0.72
Tare per seat (kg)	1 435	2 289	1 740	1 053	687	939	660	212	347.5	276	480
Tare per m^2 of available area (kg)	1 209	1 429	1 128	748	474	1 034	770	365	630	408	628
Tare per m of set length (kg)	2 478	2 855	2 379	1 488	962	2 074	1 800	954	1 500	980	1 490
H.P. per ton of total weight	3.38	4.74	6.74	6.06	5.98	4.68	13	—	3.88	—	3.36[1]
							Hourly power output 16.6 (starting power)				[1] For a motor power of 272 H.P.

Columns 1 to 6, cf Prof. Dr-Ing. FROHNE : Gliederzüge in Fernverkehr (Articulated rakes in long distance traffic). *Die Bundesbahn* 27 (1953), No. 12.

ET 30 that is, the driving bogie designed by the D. B. Central Office, Munich, in collaboration with Waggonfabrik Fuchs of Heidelberg, which it is now intended to adapt for installed loads suitable for locomotives, and the carrying bogies, Munich-Kassel type, of the motor coaches and the central, non-driving coach, have, with dynamometer car tests on the line, given some remarkable results which are outside the scope of this article even though the conditions imposed by the exceptional nature of the motor equipment and a drive by means of heavy nose-suspended motors had at first given rise to doubt.

When the general features of the ET 30 are compared, from the point of view of *rolling stock construction,* with those of other vehicles (Table 6), it must not be overlooked that the tractive powers for which the ET 30 was designed are of a different range than those so far used. This reservation is necessary to measure the progress expected from this new motor coach set by the D. B. and the latest achievements of the German rolling stock industry. So far twenty-four ET 30 motor coach sets have been ordered. Of these, sixteen were put into service before August, 1956. They will firstly be used exclusively in Southern Germany and, with the introduction of electric traction in the Ruhr region, seven sets will run in Eastern Germany. The lack of modern motor coaches has not allowed the construction of an experimental prototype which would only have increased the responsibilities of the design staff especially as the only testing station for the rolling stock builder is the open track. After a suitable period of operation with the first series of the ET 30, the construction of new sets can be expected fairly quickly. This set is notable, even externally, and has captured public attention by giving electrified lines a new appeal. The most recent set is experimental for testing different types of drive, especially disc brakes and their behaviour in heavy services with frequent stops. It will also be fitted with a magnetic rail brake of a new type.

The general design is by the Federal Railways Cental Office, Munich; design of the motor coach and driving bogie was given to the Waggonfabrik Fuchs of Heidelberg, the central coach and interior equipment to the « Waggon und Maschinenfabrik Donauwörth »; the carrying bogie to the « Waggonfabrik Wegmann und Co. » of Kassel.

Apart from the above, the companies which have participated in the construction of the coaches and bogies are the « Vereinigte Westdeutsche Waggonfabriken » of Cologne-Deutz, the « Düsseldorfer Waggonfabrik » and MAN of Nuremberg.

The following contractors were also concerned in the work of design and erection :

Components.	Firm.
Driving wheels	Bochumer Verein Bochum.
Carrying wheels	Ruhrstahl A. G., Henrichshütte.
Driving axleboxes	Kugelfischer Georg Schäfer A. G.; S. K. F. Kugellagerfabrik; G. J. Jaeger GmbH.
Compressed air brake	Knorr Bremse A. G.
Centre buffer and drawgear	Scharfenberg Kupplungs GmbH.
Inner and outer gangway covers	Waggon- und Maschinenbau GmbH, Donauwörth and Rheinische Gummi- und Celluloidfabrik.
Doors	Arn. Kiekert Söhne.
Lighting fittings	Pintsch Elektro, GmbH.
Seat frames	Bremshey & Co.

[625 .2]

Contribution to the evaluation of comfortable running of railway vehicles

(Note from the Rolling Stock Testing Department of the DB),

by Dr.-Eng. E. Sperling and Dipl.-Phys. Ch. Betzhold, VDI, Minden (Westphalia).

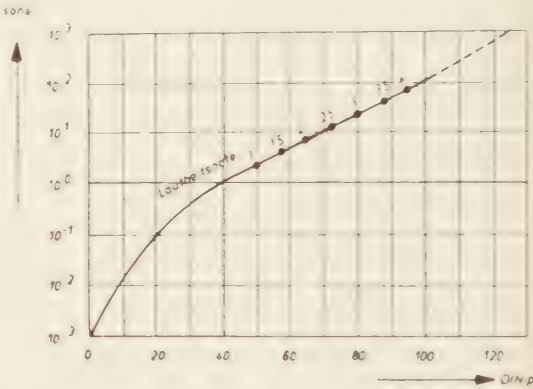
(*Glasers Annalen*, October 1956.)

The Bundesbahn is taking energetic steps to improve the comfortable riding of passenger coaches; it is endeavouring to improve the air conditioning and lighting, and to reduce noise and vibration.

The measurements effected in the domain of the construction of the stock have two objectives in view : on the one hand, it is a question of determining the comfortable riding, as experienced by passengers, and on the other of supplying information to the engineers designing the stock in order to obtain improvements. In the following study, we will deal with the subjective evaluation of running noises and vibrations.

1. **Estimation of running noises.**

In the Rolling Stock Testing Department, running noises are measured by means of soundmeters in accordance with the DIN 5045 standard. The measured values of the sound transmitted through the air are indicated either in decibels, according to the objective scale (independently of the frequency), or in subjective scales in phons or in sons (1) (fig. 1). The last two scales of measurement take into account the sensitivity of the human ear to the frequency. Measurement in sons has the advantage of allowing of the addition of the components of the different bands of frequency to obtain the total noise, or a comparison with a sinusoidal sound of the same intensity. The great difference between the subjective and objective methods of evaluation is shown in figures 2 and 3 (2). However, these scales are not used to any great extent in mechanical design; so that it appeared advantageous to adopt in addition



phon	0	1	2	3	4	5	6	7	8	9
40	1,00	1,08	1,17	1,26	1,36	1,47	1,59	1,71	1,85	2
50	2,15	2,33	2,51	2,71	2,93	3,16	3,41	3,69	3,98	4
60	4,64	5,01	5,41	5,84	6,31	6,81	7,36	7,94	8,58	9
70	10,0	10,8	11,7	12,6	13,6	14,7	15,9	17,1	18,5	2
80	21,5	23,3	25,1	27,1	29,3	31,6	34,1	36,9	39,8	4
90	46,4	50,1	54,1	58,4	63,1	68,1	73,6	79,4	85,8	9
100	100	108	117	126	136	147	159	171	185	2
110	220					320				
120	470					1000				

Fig. 1.

N. B. — Lautheitsnote = note of sonority.

(1) Cf. W. Bürck (1) and G. Quietsch (3).

(2) Reference frequency : 1 000 Hz.

in the construction of rolling stock simple notes for the evaluation of the different noises and to make these known. It is with this method of notation that we shall deal in the present article.

After examining the documents relating to the investigations made by the Test Department, in 1954, the diagram reproduced in Table 1 was got out.

G. Steinicke (7) evaluates running noises as follows :

110 phons Beginning to be dangerous;
100 phons Definitely tiresome;
80 phons Beginning to be tiresome;
60 phons Hardly troublesome.

Besides these sonorous vibrations transmitted through the air, there are also other vibrations. These are mainly vibrations made up of heavy frequencies, due to the actual running of the vehicle ([3]).

TABLE 1. — **Diagram for the evaluation of noises.**

Note	Phons DIN	Sons	Fatigue time T	Appreciation
4.0	more than 95.0	more than 68	1.5	Should not be imposed
3.5	87.5	38.4	2.8	Hardly supportable
3.0	80.0	21.5	5.6	Passable (Can be asked for)
2.5	72.5	12.2	13.0	Good to passable
2.0	65.0	6.8	More than	Good (weak)
1.5	57.5	3.9	24 hours	Very good to good
1.0	less than 50.0	2.2		Very good (very weak)

This diagram of notation is applicable to the average noises during a long journey in a compartment in the middle of a passenger coach at a speed of 80 km/h. (50 miles).

As the production of noise is not uniform, it is necessary to determine the average general noise level L_{ges} by means of the formula :

$$L_{ges} = 20 \log \sqrt{\frac{t_1 p_1^2 + t_2 p_2^2}{t_{ges}\ p_0^2}}.$$

In this formula, t_1, t_2, ... represent the duration of the different part sections p_1, p_2 ... the sonorous pressures in these part sections and $p_o = 2.10^{-4}\mu$ bars the value of the noise level. It is thus the most intense noise which governs the notation of the whole.

For the sake of completeness, we have given in addition the fatigue times : this is the time at the end of which the passenger begins to feel tired.

Recent publications agree very closely with our notation.

2. Evaluation of the vibrations of the coach.

To establish and fix a uniform method of evaluation of the riding of vehicles, a series of studies were carried out in 1941 by the Rolling Stock Test Department of the Reischbahn at Berlin-Grunewald.

The quality of rolling of a coach is determined, in the case of vibration, by the acceleration $\frac{d^2y}{dt^2}$, the impulsion $\frac{d^3y}{dt^3}$ (vari-

([3]) The noise of solids is composed of definitely higher frequencies and of smaller amplitudes. Cf. E. Sperling, Ch. Betzhold and H. Jilek : *Beitrag zur Frage des Körperschallanteils am Innenfahrgeräusch im Reisezugwagen* (Contribution to the question of the components of the noise of solids in the running noise inside passenger coaches). *Rohde und Schwarz Hausmitteilungen*, Munich, 8 (1956), p. 13-18.

ation of the acceleration in the unit of time and the work of the unit of mass:

$y \frac{d^2y}{dt^2}$ amplitude of oscillation x acceler-

ation. With the hypothesis of a sinusoidal vibration, to the amplitude a and frequency f in Hz we get : maximum acceleration = $a\ (2\pi f)^2$, impulsion = $a\ (2\pi f)^3$, and work of vibration = $a^2\ (2\pi f)^2$.

As basis for the evaluation of the riding quality, there is the expression $c\ a^3 f^5$ which consequently represents the product of the work by the impulsion = $a^3\ (2\pi f)^5$.

As far as the individual is concerned, however, the sensation of vibrations (shocks) is not directly proportional to the intensity of the shock, but varies according to an exponential law. For the intensity of sensation, there is the expression :

$$I = C \sqrt[n]{a^3 f^5}.$$

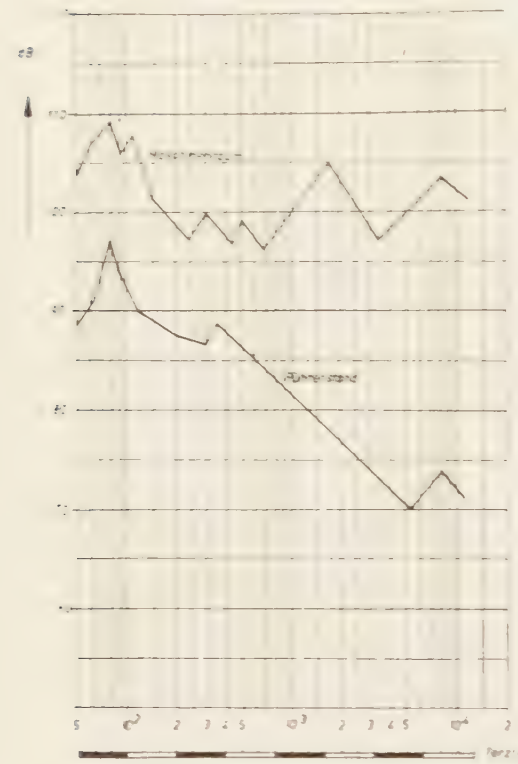


Fig. 2. — Analyses of frequencies (Teva filter). — Noise transmitted through the air in the engine compartment and driving compartment of a Diesel locomotive at 70 km (44 miles) h.

N. B. — Maschinenraum = engine compartment. — Führerstand = driving compartment.

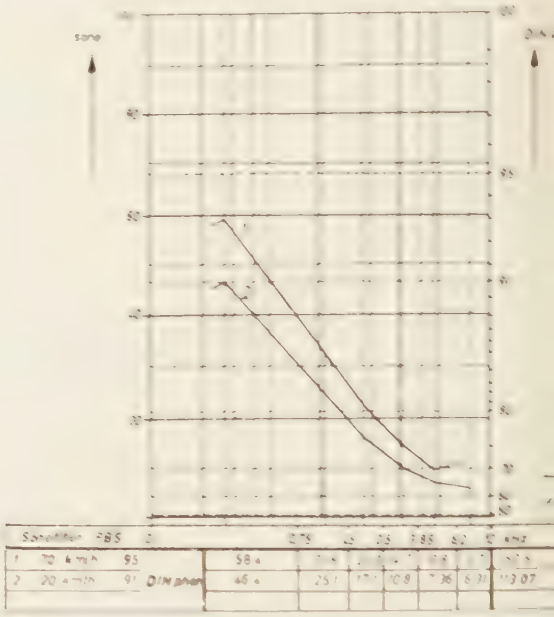


Fig. 3. — Values measured by the EZGN noise level indicator and by the PBS filter (sons).

Intensity of noise measured without analysis	150.6	113.07	DIN phons
True sonority with analysis	95	91	sons
corresponding to	105.5	102	DIN phons for a sinusoidal sound of the same intensity.

and for the coefficient of evaluation of the riding quality, the formula :

$$W_z = 2.7 \cdot \sqrt[10]{a^3 f^5}.$$

In these expressions, a is the amplitude in cm and f the frequency in Hz. As the acceleration $b = a\ (2\pi f)^2$, we can also write :

$$W_z = 0.896 \sqrt[10]{\frac{b^3}{f}};$$

b being the acceleration in cm sec^2.

The riding quality of a coach, as is known, is not uniform over a long distance

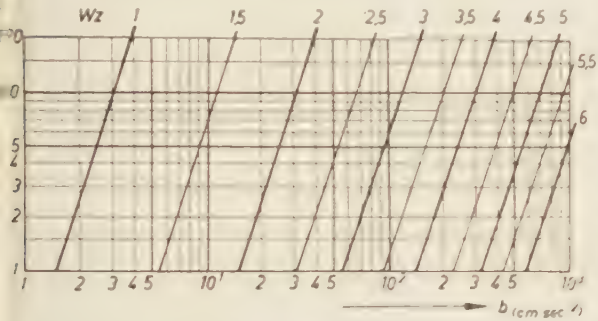


Fig. 4.

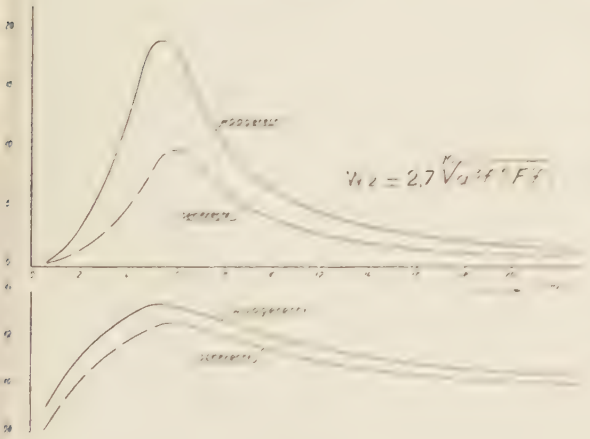


Fig. 5.

N. B. — Waagerecht = horizontally. — Senkrecht = vertically.

even if the speed remains constant. To evaluate the quality of riding of a coach, a general note is therefore always established for a fairly long section (5 to 10 km = 3.1 to 6.2 miles), according to the formula :

$$W_{zg} = \sqrt[10]{\frac{n_1 W_{z_1}^{10} + n_2 W_{z_2}^{10} + n_3 W_{z_3}^{10} + \ldots}{n_1 + n_2 + n_3 + \ldots}}$$

In this formula, n_1, n_2 ... are the lengths of the different part sections.

With this formula, it is the worst riding qualities that determined predominantly the general note of the riding quality; in fact, the riding of a coach must be classed as poor if it is bad for only 10 % of the journey, even if it is very good for the remainder.

Recently, a corrective factor has been introduced into the formula of the note of the riding quality, in order to take human reactions more closely into account. The corrected formulae for the riding quality then become :

$$W_z = 2.7 \sqrt[10]{a^3 f^5\ F\ (f)}$$

or

$$W_z = 0.896 \sqrt[10]{\frac{b^3}{f}\ F\ (f)}.$$

In figure 4 the variation in the evaluation notes has been shown as a function of the frequency and acceleration, and in fig. 5, the correction factor $F\ (f)$ and $\sqrt[10]{F\ (f)}$ as a function of the frequency, separately for the horizontal and vertical stability of the coach.

As when measuring the noise, it is also possible to obtain the notation of the riding quality in the form of Weber-Fechner's law

$$E = C \log \frac{R}{R_o},$$

C = constant coefficient, R = intensity of excitation, R_o = excitation level.

Replacing R_o by the value of $a^3 f^5$ for just perceptible vibrations ($W_z = 1$), the formula W_z then becomes approximately

$$W_z \approx 0.66 \log \frac{a^3 f^5}{4.35 \cdot 10^{-6}}$$

An evaluation method established according to the formula W_z is also suitable for passenger coaches as well for wagons. The Rolling Stock Test Department has gradually built up the following standardised designation of the riding quality mark (note W_z) (4).

$$T_{ges} = \frac{t_1 + t_2 + t_3}{\frac{t_1}{\tau_1} + \frac{t_2}{\tau_2} + \frac{t_3}{\tau_3}}.$$

In this formula, t_1, t_2 ... are the durations of the times of the measurements during which the fatigue times τ_1, τ_2 ... were noted.

TABLE 2. — **Riding quality notes.**

Mark W_z	Vert./horiz. acceleration b (cm/sec²)	Pal	Fatigue time T (hours)	Appreciation
1.0	1.3 1.5	13 14	more than 24 hours	Very good
1.5	4.8 5.3	23 24		Almost very good
2.0	13.2 14.5	33 34		Nearly good
2.5	27.0 29.7	39 40	13.0	
3.0	49.0 54.0	44 45	5.6	Passable
3.5	81.5 89.5	48 49	2.8	Still passable
4.0	132 145	52 53	1.5	Able to run
4.5	193 214	56 57	95 min.	Not able to run
5.0	274 300	59 60	55 min.	Dangerous

The note $W_z = 3$ to 3.25 has been laid down and defined as the lower limit of riding quality still acceptable in the case of passenger coaches, and

the note $W_z = 4$ to 4.25 in the case of goods wagons.

The agreeableness of the journey can be characterised by means of the fatigue times. (5) The time at the end of which passengers begin to feel tired is the essential criterion for the appreciation of the agreeableness of the coach being tested from the point of view of its riding. Under varying conditions, the average over-all fatigue time is determined as follows :

The evaluation of the vibrations of the vehicles also agrees very closely with the data given by the authors who have dealt with this question. The data given by W. ZELLER (8) are shown in figure 6 and those of H. REILER and F.J. MEISTER (4) in figure 7.

By analogy with acoustics, W. ZELLER (9) has expressed the intensity of the sensation of vibration S by the formula :

$$S \text{ (pal)} = 20 \log \frac{b}{b_0}.$$

In this formula, b_0 is the threshold of sensation which is a function of the frequency (6).

(4) Reference frequency 1 Hz.

(5) The evaluation of riding quality according to the fatigue times and the determination of the value of the amplitudes of the acceleration at different frequencies has been made in collaboration by M. MAUZIN, Chief Engineer of the S.N.C.F. at Paris and Dr. E. SPERLING, Bundesbahnoberrat at Minden (Westphalia).

(6) Threshold of sensation : $x_0 = 0.008$ cm, $v_0 = 0.05$ cm/sec — respectively $b_0 = 0.316$ cm/sec² referring to a frequency of 1 Hz.

3. Over-all evaluation as a function of the rolling noise and of the steadiness of riding.

G. v. Békésy, amongst others, has studied the conductibility of the human body to vibrations. The components of frequency from 0 to 6 Hz pass through the whole of the body without obstacle. It is only above 6 Hz that owing to the effects of resistance of certain parts of the body, there is a marked filtering effect. For example, with a person standing, all the frequencies higher than 80 Hz are already absorbed between the sole of the foot and the ankle. Only frequencies of $f = 20$ Hz will reach the heart. For the above subjective evaluation, it is therefore possible to leave aside to a certain extent the noise transmitted by solids.

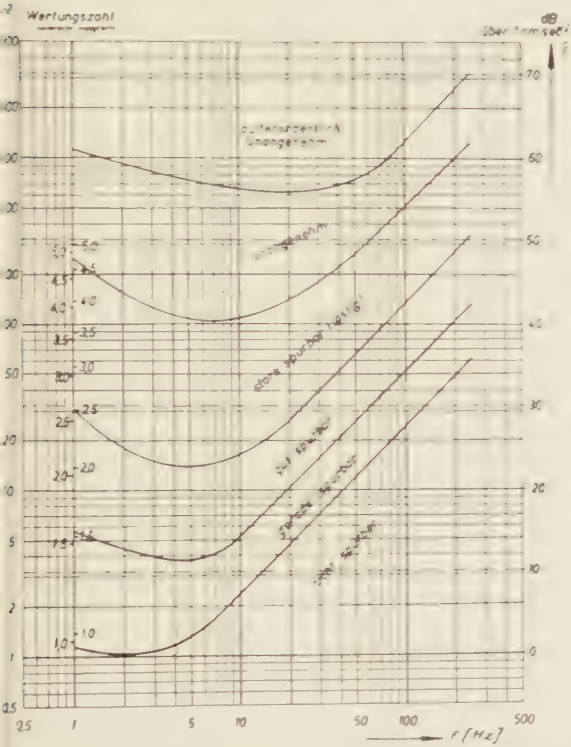


Fig. 6. — Fields of equal intensity of sensation of the vibration according to H. Reiler and F.J. Meister.

N. B. — Wertungszahl, waagerecht, senkrecht = Note of appreciation, horizontally, vertically. — Ausserordentlich unangenehm = extremely disagreeable. — Unangenehm = disagreeable. — Stark spürbar (lastig) = very appreciable (tiresome) .— Gut spürbar = definitely appreciable. — Gerade spürbar = only just appreciable. — Nicht spürbar = unappreciable.

Proposals have been put forward for the subjective evaluation of the comfort of riding, especially as regards noise and stability.

By using notes of appreciation or fatigue times, it is possible to establish an over-all evaluation of the comfort of riding based on the following equation :

$$W_{z_{ges}} = \sqrt[10]{(W_{z_{noise}})^{10} + (W_{z_{running}})^{10}}$$

The worst note of quality calls for separate evaluation, as well as for its over-all evaluation.

This method of evaluation can also be applied to the lighting, the heating, air conditioning, etc.

The suggested subjective criteria evaluate the sensation experienced by the man, the passenger, and therefore only give a general idea of the comfort of riding. Other studies will be needed based on objective criteria, in order to be in a position to submit definite propositions to the designer, enabling him to improve the vehicle and bring it up to the standard of the note of evaluation aimed at.

We have purposely omitted to describe the measuring equipment and any special characteristics, as these have been dealt with in previous publications.

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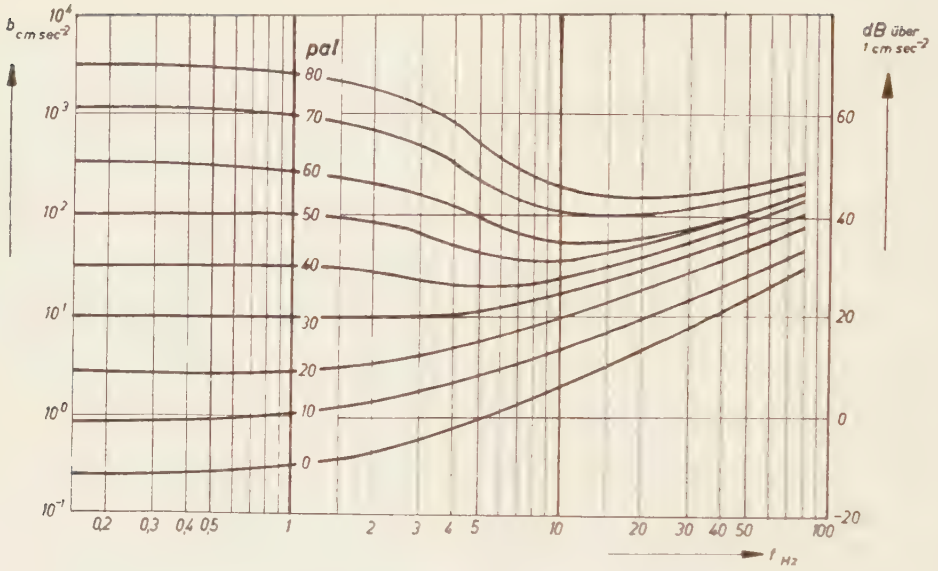

Fig. 7. — Intensity of sensation of the vibration (pal) as a function of the acceleration and of the frequency according to W. ZELLER.

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[385 .58 (44)]

The rehabilitation centre for injured persons at Vitry-sur-Seine,

by R. Bois,

Chief Engineer of the Rolling Stock and Traction Department of the French National Railways,

and Dr. J. Chevreau,

House Doctor at the Vitry Shops of the South-Western Region of the French National Railways.

(*Revue Générale des Chemins de fer*, November 1956.)

What is meant by rehabilitation?

In its etymological meaning, the word rehabilitation means restoring to someone who has been disabled all the aptitude he had before he was injured or sick, and consequently putting him back in the same physical, social, functional and economic state.

The moral and material value of such treatment becomes immediately apparent when it is remembered that in France, in spite of all efforts, there are still about 150 000 cases of casualties resulting in permanent incapacity, half of them of at least 10 %. About 70 000 of these cases are due to accidents at work, and it is a well known fact that accidents, even slight ones, may give rise to important functional consequences quite out of proportion to the gravity of the injury sustained.

In so far as it will make it possible to avoid such incapacity or at least reduce it, rehabilitation of injured persons has a very important economic and social role to play in industry. The S. N. C. F. which is the largest industrial undertaking in France could not remain indifferent to such a problem.

History.

As far back as 1949, the Western Region was the first to carry out experiments with passive re-education, in particular the Rolling Stock Shops at La Folie. One year later, an engineer of the South-Western Region was sent on a mission to England to study the rehabilitation methods practised there for some twelve years in certain large industrial centres, especially at the Vauxhall Motor Works and the adjacent hospital at Dunstable.

In December 1950, the medical services of the South-Western Region decided to make a practical trial in the Vitry-sur-Seine shops in connection with injured railwaymen of the Paris district.

A specially adapted machine tool to treat traumatism of the shoulder was installed in the shops; then, in the light of the experience obtained and information collected by a medical team of the region during an educational trip to England, it was decided to set up a separate centre, adjoining the shops, equipped with the necessary apparatus and staff. Opened in 1952 with four posts for treatment, it was progressively extended until there were already 19 when it was officially inaugurated on the 13th May 1954 by the General Manager in the presence of many eminent personalities of the S. N. C. F. and the medical world.

Since then it has been the object of continuous studies and improvements, and at the present time, it seems possible to judge its efficiency and draw from it certain general conclusions regarding the experience obtained.

Installations and equipment.

The principle of the methods used for rehabilitation are well known. They consist of occupational therapeutics which

endeavour to capture the attention and willpower of the patient by making him accomplish some useful work by means of a combination of passive or active automatic gestures resulting in the functional re-education of the injured part.

The application at the Vitry Centre consists in requiring the patient to operate a machine tool the controls of which are fitted with suitable devices for his particular case which give him a passive-active or activo-passive mecanotherapy according

— a rest room, to which the men have free access all day;

— an office for the supervisor;

— a store where the collection of control devices is stored.

The machine tools used are reconditioned units, which have been overhauled to make them adequate for the purpose in question.

They consist of :

— sensitive drills (1). This is the type of machine which lends itself best to the

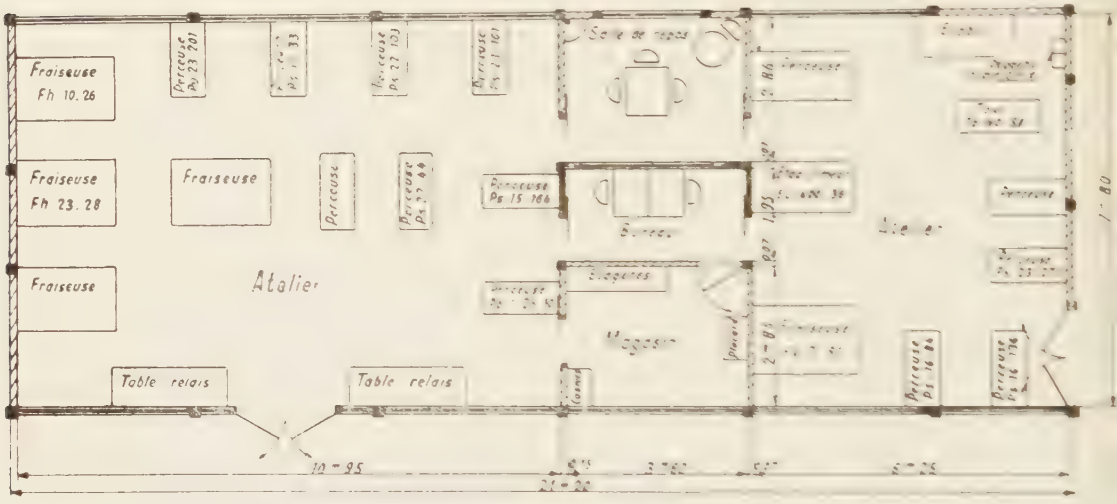

Fig. 1. — Plan of the Vitry Rehabilitation Centre.

Explanations of French termes :

Atelier = workshop. — Fraiseuse = milling machine. = Perceuse = drilling machine. — Salle de repos = rest room. — Magasin = store. — Bureau = office. — Etagères = shelves. — Etau limeur = shaping planer. — Tour = lathe.

to the individual case, whilst his mind is occupied by supervising the work done by the machine. These devices are removable.

The Centre then is planned as a machine tool shop capable of dealing with all the different cases that may be presented.

Installed in a separate building, it is close to the administrative department of the shops (fig. 1). It includes, on a floor 165 m² in area :

— two well-lit workrooms, in which there are 19 machine tools, each forming a treatment post;

fitting of the different gadgets. No special apprenticeship is required to learn how to operate it which makes it very suitable for the Centre which takes men of all grades from every department;

— milling machines. These, for the reasons explained above, are being replaced by drills. It is moreover difficult to find enough very simple work for them to do;

— a shaping-planer.

(1) Fixed drills of small capacity with hand feed by lever.

Finally, the Centre has its own equipment for making the different gadgets (lathe, oxyacetylene set, [illegible]).

The working of the Centre

Technical management

Administratively, the Centre is attached to the Vitry Shops. But the [illegible] [illegible] which the technicians of the workshops, on which progress has been made and decide if the patient is well enough to return to his unit/ward.

The centre thereby gives an knowledge of the work done and the possibilities and functional improvements that prosthesis may provide. Owing to his specialized knowledge he understands the mechanical side and controls the prosthesis he makes good to the surgeon

Fig. 2 — The amputee learns to use his new limb. His walking ability is judged by the doctor and by himself. The arrangement seen on the patient's shoulder is to prevent him dropping [illegible] to keep his shoulder [illegible].

agement is assured by a surgeon and a [illegible] doctor working in close collaboration, while the services of a technician are also available.

The surgeon gives his clinical and therapeutic knowledge of diseases which are mainly surgical. He outlines theoretical cases which can be treated effectively and decides the order of urgency in admissions [illegible] to the Centre as places become available. Once a week he visits the shops to [illegible] and [illegible] the amputee, and, when progress has been made and he feels it is time, he will arrange to return the [illegible] to his unit/ward.

The centre doctor gives an knowledge of the work done and the possibilities and functional improvements that prosthesis may provide. Owing to his specialized knowledge he understands the mechanical side and controls the prosthesis he makes good to the surgeon

The technician is a gang foreman permanently attached to the Centre. He is specially selected on account of his character and his aptitude in studying, carrying out and perfecting the gadgets suggested by the doctor. Under his technical direc-

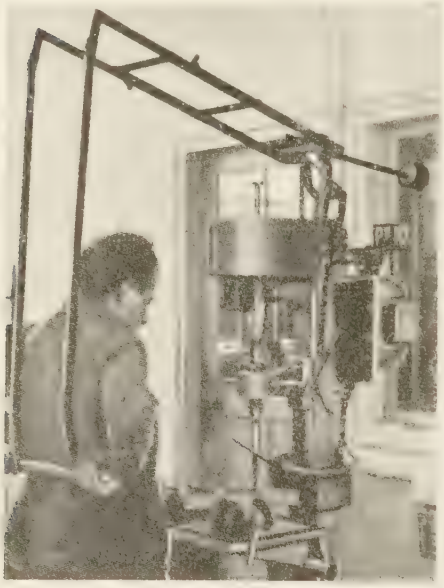

Fig. 3. — This gadget is intended to achieve movement of the shoulder joints.

tion, he supervises and directs the patients and checks that the doctor's orders are being carried out in each case. He directs the apprenticeship which is often necessary at the beginning of treatment, since he often has patients who have never seen a machine tool as well as workmen. During the treatment, he regulates the machine tools according to the progress made by the patient.

The creative imagination he shows, the perfection of his technique, the understanding of the physically disabled which he must possess, make him an essential auxiliary and complement of the medical team responsible for the running of the Centre.

Selection of the injured persons to be treated.

The injured persons comes from the establishments of the Paris area of the Region.

Those suitable for treatment at the Vitry Centre are nominated by the surgeon of the medical centre of Paris-Austerlitz who also looks after the surgical side of the Centre. They are sent to him for this purpose by the doctor treating them to be examined by him as soon as they are well enough to get up.

Experience has shown in fact that it is of the greatest value to act as soon as possible to cancel the effects of articular ankylosis and amyotrophy.

Fig. 4. — This gadget is intended to restore bending and stretching movements of the elbow and consists of a moveable lever on which the forearm rests which makes a movement of rotation around a virtual axis which must be at the height of the elbow joint. By moving the lever from one of the toothed wheels to the other, the bending movements can be altered to stretching movements.

Treatment.

Most of the injured persons treated at the Centre suffer from some degree of functional impotence, due to ossicular or articular lesions, or to muscular hypotonia. These functional consequences often are out of all proportion to the lesions which caused them.

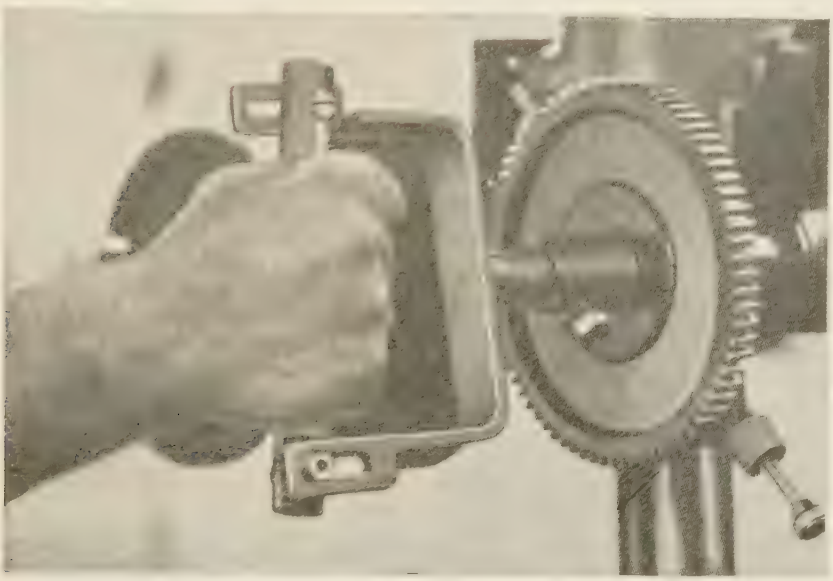

Fig. 5. — Ratched apparatus intended to restore rotary movement of the forearm (pronosupination). Very economical from the point of view of consumption of raw materials, it requires thirty to forty movements to make a simple hole.

The principle of rehabilitation consists in systematically restoring articular motility by means of so called passive mobilisation equipment, and then to restore muscular tonicity by active mobilisation. Certain equipment also makes it possible to combine the two.

In practice all the gadgets force the damaged limb to make either a movement of rotation or of flexion and extension reproducing normal physiological functioning.

The complexity of the first mechanisms often made it necessary to fabricate several gadgets for a single case. The diversity of the movements to be made, and the variation in size of the individuals, involve a great deal of adjustments being essential to obtain accurate regulation of the equipment, but all this led to a loss of time prejudicial to the proper user of the Centre.

Profiting by the experience acquired, the gadgets that have been constructed recently are very much simpler as a result of successive improvements. Their polyvalence, the ease with which they can be regulated in all dimensions, have made it possible to reduce the number to some dozen types which can be used in nearly every case.

They consist of various simple mechanical combinations such as : cams, gears, ratchets, levers, rods or other combinations in ordinary use, such as the differential.

Figures 2 to 10 show the most characteristic types used.

The rhythm of the work is based entirely

on the progressive restoration of the function, which in its turn is closely linked up with the interest the patient feels in his work. Experience has shown in this connection that it is essential to let them

Fig. 6. — The originality of its mechanism, the simplicity of its design, makes it possible to use this gadget both with the left hand and with the right hand, and for stretching as well as bending.

do useful work, quite apart from any question of productivity which does not come into this matter at all.

The free use of the rest room as often as necessary gives the necessary relaxation.

Auxiliary treatment by qualified persons (infra-red, diathermy, short waves) is also given systematically.

The length of time spent at the Centre necessarily varies according to the nature of the lesions. Usually, between fifteen days and three months, in every case, the sooner the injured person is treated, the quicker his progress.

Results obtained.

Since being founded, the Centre has treated 171 injured persons who have all been able to return to their previous jobs, without any permanent incapacity in most cases.

The statistics for the first hundred cases treated show that :

Number of injured persons leaving without any permanent residual handicap = 77.

Number of injured persons leaving with some permanent residual handicap = 23, divided up as follows :

4 with between 40 and 20 % residual handicap;

7 with between 20 and 10 % residual handicap;

12 with between 10 and 0 % residual handicap.

It must also be noted that some of these had had amputations which obviously cannot be made good.

Administration.

The injured person whatever department and work he belonged to is attached to the shop. He is counted as having returned to work with the resultant wages and bonuses he is entitled to. From the accountancy point of view, his wages are charged up to his original department which would have been responsible for them.

The cost of running the centre, namely the salary of the supervisor and the running costs (manufacture of gadgets, maintenance of the machine tools and building, and electricity used) are debited to the

« Cost of re-education », column of the general charges. The parts machined by the injured persons (wearing strips of electric locomotive pantograph shoes, sheet hooks for wagon end boards, belt points, pallet angle strengthening irons, etc.) are sold to the departments using them at a fictitious cost price corresponding to the cost of the same part when machined in the Vitry shops. The corresponding sums help to meet the cost of running the centre.

Obviously, there is no question of normal costs being obtained, as the object in view is something quite different. But is should be noted that by careful selection of the parts to be machined and simplification of the arrangements, it is now possible to obtain actual costs not more than three to four times higher than the normal cost.

Under these conditions the cost of administration is balanced by the receipts.

Conclusion.

The Management of the South-West Region of the S. N. C. F. faced with the serious problem of accidents at work found it necessary and of value to study the

Fig. 7. — Modification of the previous gadget for stretching the fingers.

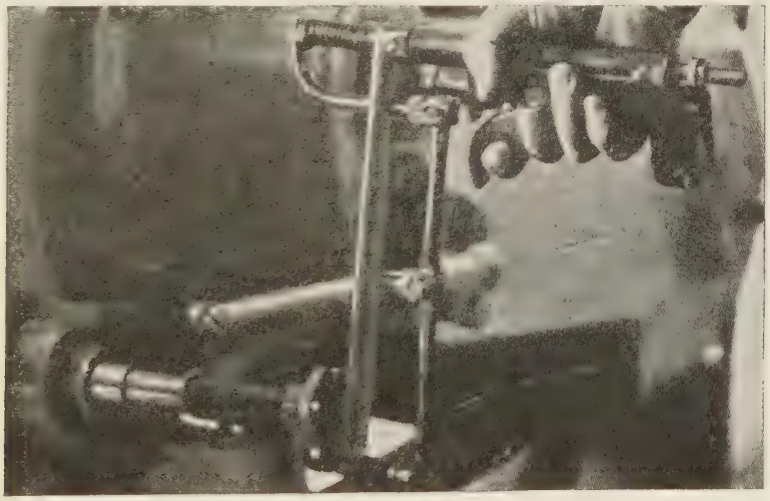

Fig. 8. — This gadget treats atrophied muscles of the fingers as soon as movement has been completely restored to the joints.

problem of rehabilitation and set up an experimental centre, limited for the time being to the type of injuries most frequently met with on the railway, to limbs and joints, and to that part of the Paris area lying within its territory. It has paid the most careful attention to British experiments in this field, and especially to their methods. But if Vitry is based on their experience, it has certain original features of its own and the experience of six years has made it possible to formulate certain simple basic ideas, valid for every large industry or group, which can be seen in

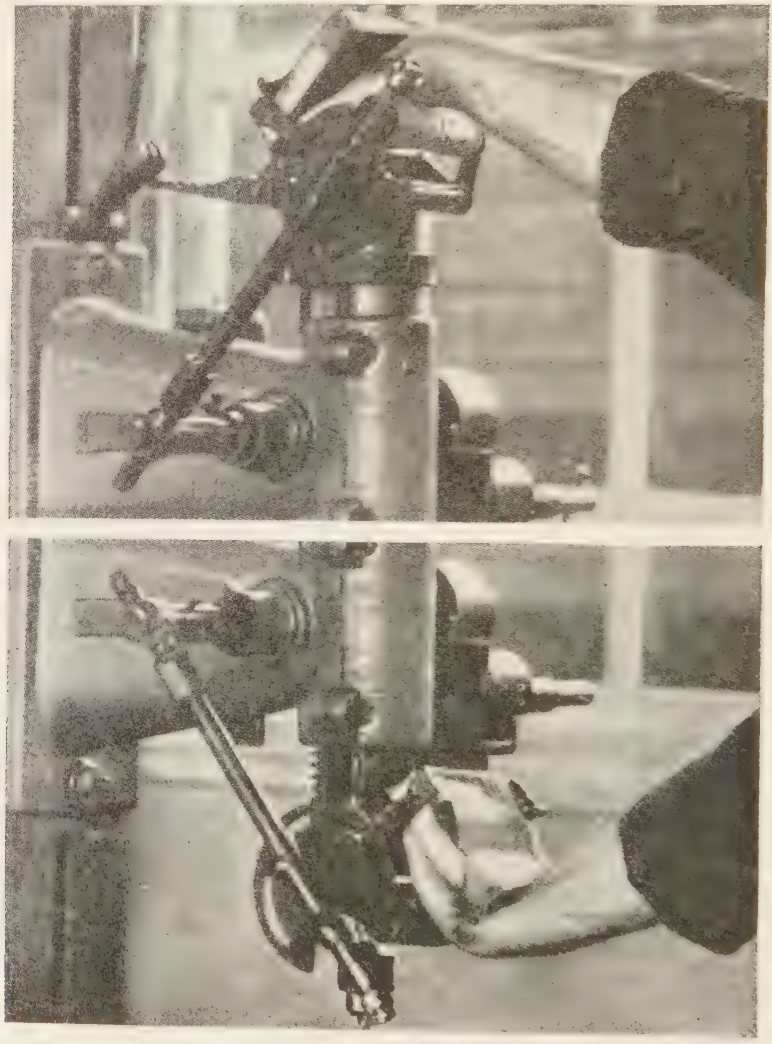

Fig. 9. — A simple rotation of 180° makes it possible to stretch or bend the wrist at will.

actual practice in the particular case of a railway undertaking.

These are based on the following essential principles :

— the most favourable atmosphere is that which allows the patient to return to his work; experience shows that it is not necessary for him to go back to his original place of work, so long as he can work somewhere like the place with which he is familiar. This avoids all the complications inevitable in the case of a widely dispersed undertaking (it should be noted that the English examples are to be found in the heart of very large concentrated undertakings [Vauxhall, Austin]).

In fact, the Vitry centre is attached to a large Rolling Stock and Traction service department, but it is completely separate from the shops and those being treated at the centre, though coming from widely different departments (Working, Rolling Stock and Traction, Permanent Way and Buildings) will find themselves quite at home though in a medical setting which will favour their return to health and be adapted to their own personal requirements.

One of the most characteristic manifestations — and one of the most useful — of this endeavour to make the patients feel at home is that they confide to the doctor in charge their personal observations about their injuries and the progress of their convalescence, and some of them even suggest useful improvements to the apparatus;

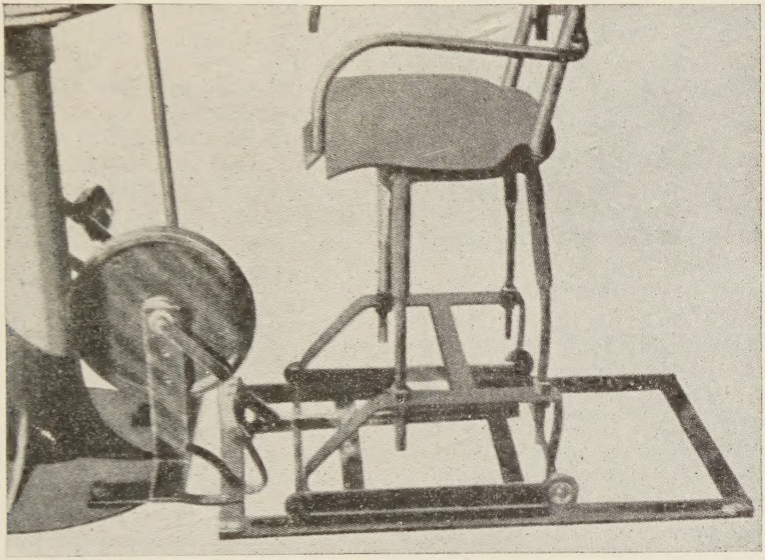

Fig. 10. — Adjustable at will, this gadget makes it possible to move all the joints of the legs separately or simultaneously.

— the interest of the work the patient is made to do must be of general interest to all the patients : not only are the departments and groups to which they are attached widely different, but they vary in grade from simple labourer to engineer.

Experience has shown that an extremely simple operation (drilling with a sensitive drill) meets these conditions, and contrary to what might have been expected *a priori*, does not lead to any slackening of effort due to monotony. On the contrary, it

has been found that there is competition between the patients or that a patient will develop the usual and understandable wish to beat his own record from one day to another;

— it is possible to devise gadgets adapted to all the types of injuries which occur to the joints for this operation. These are based on a small number of very simple types. The simplicity and polyvalency of these gadgets have only been obtained at Vitry after long and patient researches and close collaboration between the work of the doctor and the technician;

— the object in view must not be to get a certain output from the patient. Though it is obviously of value for his work to be useful, this must not be made the end in view, and all that was required was to find administrative and accountancy methods sufficiently flexible and reasonable to « associate » the life of this medical centre with the industrial management of the undertaking.

On the other hand, it must not be forgotten that experience has proved that work for its own sake without any useful objective defeats its own purpose.

The solution chosen in the particular case of the Vitry centre leaves the patient quite free; he suffers no material loss from the treatment and he is not bound to adhere to any minimum production, whilst the costs of running the Centre are appreciably reduced by crediting it with the sale at the usual price of all the parts machined by the patients, no matter what they actually cost.

The efforts made by the free will of the patient, are much more effective under these conditions and the moral aspect of the problem dealt with from this angle is certainly one of the factors of its success.

That Vitry has been successful is indisputable. But to what can this success be translated into actual figures ?

It must be recognised that in practice it is quite impossible to calculate the reduction in the permanent incapacity of the patients. Though there are some cases where the patient could certainly never have recovered the use of all his faculties unaided, there are others where there is nothing to prove that time and nature unaided would have led to his recovery, and between these two extremes there are many intermediate cases. The only thing that can be affirmed is that the material balance sheet is certainly not in the red.

Again it is certainly favourable on the moral and psychological planes, and this alone fully justifies it.

Would it be possible to extend its scope ?

Certain countries have thought that it would be, and in particular England where it is proposed to use the effects of graduated work in controlled surroundings for certain medical cases.

But this is a more specifically medical matter, at the present time the subject of research, and there is no question as yet of translating it into practical realisations.

Finally, it may be concluded that the Vitry Centre is an example of what can be done, in a field which is not specifically a railway one, when the doctor and engineer act together as a team.

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